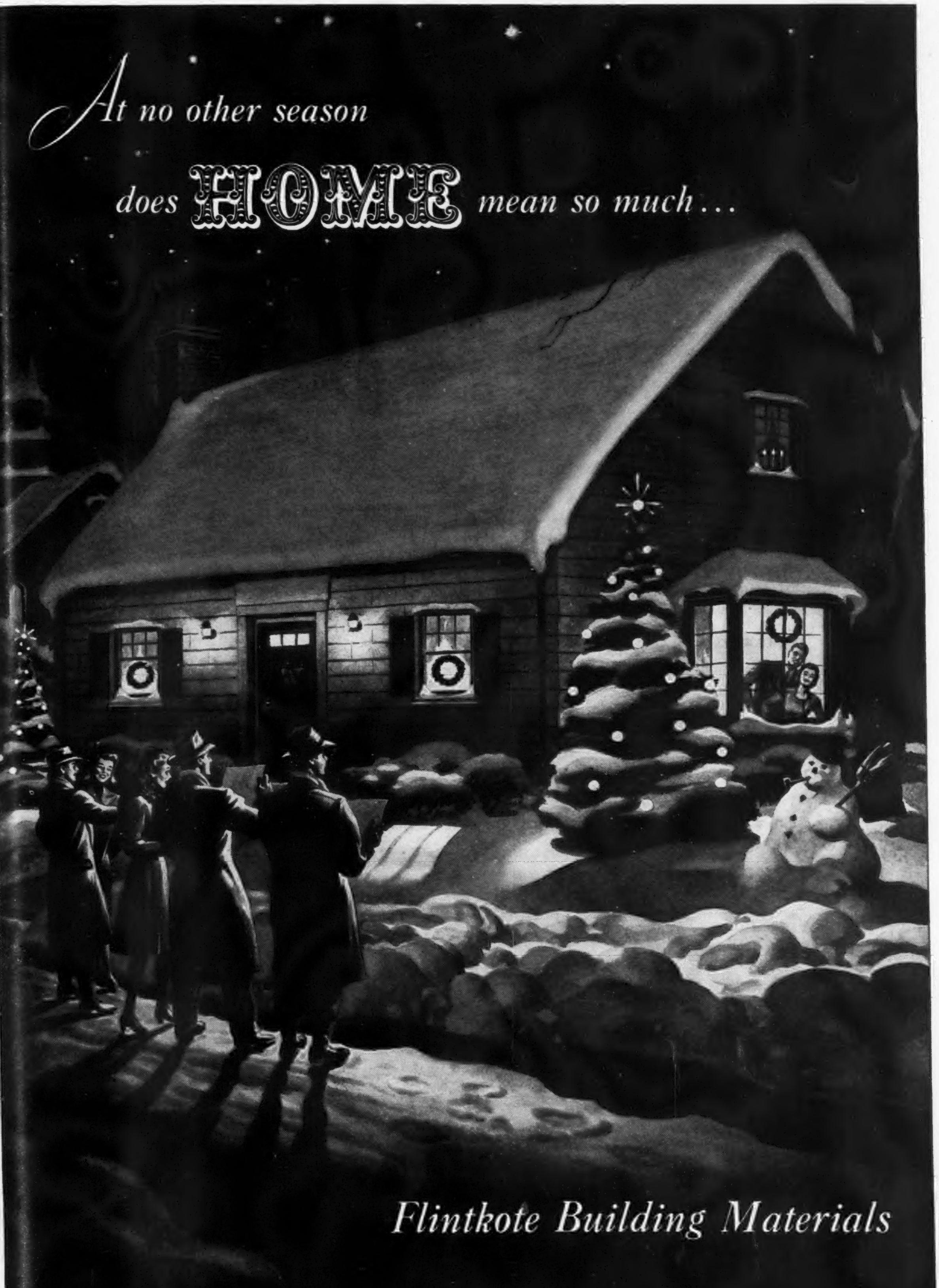
AGRICULTURAL ENGINEERING

DECEMBER · 1945

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS


At no other season
does HOME mean so much...
Flintkote Building Materials

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR DECEMBER, 1945

Vol. 26, No. 12

This Journal is owned, edited, and published monthly by the American Society of Agricultural Engineers.

Editorial and advertising departments at the executive office of the Society, Saint Joseph, Michigan. Publication office at Benton Harbor, Michigan.

SUBSCRIPTION PRICE: $3.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

EDITORIAL

Haying Upheaval

PERUSAL of the paper by C. N. Turner, appearing as the leading article in these pages, exemplifies and emphasizes the unity of agricultural engineering subject matter, despite its specialized divisions. With men of rural electrification carrying the ball at the moment, the relations to farm structures and to farm machinery are all too apparent. It is obvious also that every technique, major and minor, of hay-making practice is on trial or at least in competition with alternative methods.

Thus far we have been thinking mainly of mow curing as something to be individually designed to fit into an old barn. It remains to find out the optimum dimensions of a haymow designed specifically for forced-air curing, with due regard for fire hazard and chore-time labor in removal and feeding of the hay. Harking back to the recent paper on standardized cross sections for farm buildings and the proposed four-foot module for barns, it may be possible to correlate the various considerations to a point where hay storage space, either above a stable or as a separate structure, will be standardized in design and varying only in length.

This would seem to pave the way for factory-built ducts, tapering back from the far end to the blower unit, itself standardized for a certain mow length and matched to the corresponding duct size. Such construction should be very nearly foolproof and open the way to "package" sale by dealers and installation by farmers or rural contractors, obviating the need for on-the-spot engineering.

Before relinquishing the field entirely to electricity, however, it might be worth while to study further the possibilities of the internal-combustion engine. We should like to see an engine and a fan engineered to fit each other, the torque curves so balanced that speed and load will be inherently self-regulating, and somewhat compensatory for varying static pressure required by the amount and condition of the hay. Even the effect of combustion gases, added to the drying air, on bacterial and other activity in the hay may merit investigation.

Less Machinery Likely

ACCORDING to present indications, any plans based upon adequate supplies of farm machinery in 1946, at least the first half of the year, had better be held in abeyance. Unless farmers drop their demand for new machinery, the shortage promises to continue as severe as during the war years. It is no time to relax the machinery conservation and rehabilitation program.

We are informed that, as of last month, following a couple of years' operation at some 60 per cent of capacity, the nation's foundries have suffered a further drop to less than 50 per cent of capacity. For three years, gray iron and malleable castings have been the worst bottleneck in farm machinery materials. The abiding and now aggravated cause is lack of foundry labor.

Steel production also is handicapped by lack of man power. It is said that domestic demand alone exceeds the capacity of the undermanned mills, while export demand is so desperate that it cannot be ignored. Production and delivery schedules have been disrupted and delayed by effects of the coal strike, which caused the banking and cooling of furnaces to a greater degree than was currently apparent in the news, not to mention the repercussions on supplies of coke, gas, and pig iron.

Bearings, electrical equipment and other component parts also are in precarious position, due mainly to strikes large and small, formal and informal. Lack of a single vital part, however tiny, has the effect of halting assembly of complete machines. Lumber, likewise, plays only a small part in modern farm machinery, yet the general shortage of all lumber, plus strikes in particular spots, interferes with the special grades of lumber required.

Strikes in the farm implement industry itself already have prevented much production, and many more strikes seem to be impending. In total, directly and indirectly, they are the major monkey wrench in the wheels of farm machinery manufacture, though voluntary vacations on unemployment pay are a considerable factor.

Patents and Progress

RECENT in the news was announcement that the International Harvester Company is listing, as available for license, a thousand of its patents; further, that it intends to make all its patents so available within five years. Both the leading position of the company in the industry and the leading position which it thus assumes in patent policy promise to make this a landmark in farm machinery history.

Patent law and patent practice are a domain in which we can plead complete ignorance. But decades of casual contact with engineers and their random remarks from time to time have given us the impression that patents too often have been developed or acquired, not for usage but to prevent usage by competitors, or mayhap for problematical future use. Let us call it a defensive policy, a negative attitude. That such a policy applies to only a portion, perhaps a very small portion, of the patents extant does not make it a constructive policy.

We hope the Harvester commitment means the adoption of a positive attitude toward invention throughout the industry, and a glowing example to all industry. It is not the first industry to promote freedom of cross-licensing. Indeed, the fact that the Harvester concern is a major unit in the automotive industry might well be the source of proof that sharing of patents is wise and profitable.

It has often seemed to us that farm equipment makers have been too keenly conscious of competition among themselves, too oblivious of other industries which compete with them collectively for farm favor and farm purchasing power. De facto pooling of patents may well enhance the place of farm machinery in this broader phase of competition.

Interchange of patents has an important bearing on research. Other industries, younger industries which have grown gargantuously by aggressive research, have found that they produce a large crop of by-product patents. Research men given free rein to foray into the realm of the unknown come back with countless discoveries and inventions unsuited to commercial use by their own companies. Meanwhile, the very thing they set forth to find may turn up in the research of another company. Free interchange of patents should make such broad-gauge research increasingly economic, give strong impetus toward more extensive research, and in the realm of farm machinery bring faster advance in agricultural techniques.

• Gene Buck farms about 100 acres of land that looks as flat as a barn floor.

So he was surprised three years ago to see a gully show up in his best field. By the end of the summer, it was so deep that he couldn't get over it with the tractor.

That fall Gene was busy cutting brush and throwing it into the ditch when the County Agent came by.

"Sure, brush will help catch the topsoil," the County Agent said. "But maybe a better way to stop gullies is to keep the topsoil from ever starting to wash. A good many farmers around here are profiting by farming around the slopes."

"Never thought till now that I *had* any slopes on this farm," Gene said.

The County Agent asked Gene Buck to go with him on a soil-conservation trip around the county.

After that trip, Gene quit plowing his land as if it were flat. With a little help from the County Agent, he staked out the contours of his fields, made terraces with his turning plow. And he has followed those contours in plowing, planting, and cultivating ever since.

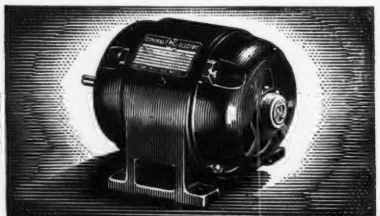
After farming around the slopes for two dry summers and a wet one, Gene figures it pays off plenty—in bigger crops and in topsoil saved. In wet years, the contours keep the topsoil from washing. And in dry years, what rain there is soaks in.

"I've put 12 per cent more corn in the bin from the same number of acres," Gene says. "By plowing right, I figure I've added 12 acres to my farm."

And Gene Buck calls this increase in the "size" of his farm "the County Agent's 12 extra acres."

All over the country, farmers are getting help from their County Agents that makes farming *better* and *easier*.

Another thing that good farmers are doing to farm better and easier is to make full use of electricity.



G-E *TRI-CLAD MOTORS ARE BUILT FOR HARD FARM DUTY

G-E Tri-Clad motors are outstanding for their *dependability* and *long life*. Tri-Clad means . . .

Extra Protection against Physical Damage . . . One-piece, cast-iron frames, and cast-iron end shield guard vital parts, keep them safe. Drip-proof construction keeps dirt and water from falling into the motor.

Extra Protection against Electrical Breakdown . . . Windings are of Formex* wire, the toughest magnet wire ever made. It resists moisture, abrasion, and heat aging.

Extra Protection against Wear and Tear . . . Sleeve bearings supply a continuous oil film over entire bearing surface. Ball-bearing mounting assures correct alignment, keeps out dust and dirt.

G-E Tri-Clad motors have no brushes, so they're *quiet-starting* and *running*, don't interfere with radio reception.

Right now they're scarce, but we are working day and night to supply G-E Tri-Clad motors to all who need them. Look for the G-E monogram when you buy a motor or a motor-driven appliance or machine.

*Trade-mark Reg. U. S. Pat. Off.

The Modern Farm Is an Electric Farm!

Electricity on a farm can make life more pleasant and work easier!

If you don't have electricity, get in touch with the electric service supplier in your area.

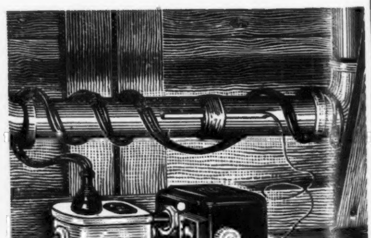
If you already have electricity, get your full value out of it by making it do more jobs for you.

To help build up modern farms electrically continues to be the job of the G-E Farm Industry Division.

Flick a switch and your feed's ground, with an automatic grinder powered by an electric motor!

Many a poultryman automatically gets whole corn for scratch feed, and crushed cobs and husks for litter, just by setting a self feeder on a corn crusher-sheller and letting the motor power the job while he attends to other chores.

And be sure to specify a G-E motor when you buy feed-grinding equipment.



Wintertime labor-saver is a length of economical G-E heating cable equipped with a thermostat.

Wrap cable around a water pipe, plug it into an outlet, and the thermostat automatically keeps the pipe at above-freezing temperature.

Thousands of farmers are using this cable on exposed water pipes, pumps, and in gutters. Limited quantities are available through G-E suppliers. See your dealer or write us.

MORE POWER TO THE AMERICAN FARMER

GENERAL ELECTRIC

669-22-155-8709

AGRICULTURAL ENGINEERING

VOL. 26 DECEMBER, 1945 No. 12

New Developments in Hay Harvesting and Curing

By C. N. Turner
MEMBER A.S.A.E.

HAY is one of the most important crops grown on New York state farms. Eighty-three per cent of our farmers grow some hay, and they average about 23 acres per farm. They grow more acres of hay than of all other harvested crops put together. The yield averages about 1½ tons to the acre, or 35 tons for each of 125,000 farms, and hay provides 44 per cent of the total feed supply for the livestock of the state. Also, hay varies more in feeding value than any other feed commonly used in dairy cattle feeding.

Therefore, any project which will help the farmer beat "Old Man Weather", and thereby improve the feeding quality as well as save a part of the crop from total loss, can certainly be justified. According to farmers' reports, our barn hay drier project at the New York State College of Agriculture at Cornell University has accomplished both benefits for them during the past two years.

Since the barn hay drier affects primarily the curing phase of the haying problem, the question is often raised as to how this new method of curing fits in with the various methods of harvesting the crop. During these past few years of critical labor and machinery shortages, many farmers have been forced to give more attention to easier and quicker methods of getting the hay from the field into the barn. While those who feed the hay have realized that the new harvesting methods have not helped to improve the quality a great deal, nevertheless they were compelled to take the crop in any condition in which it could be harvested. Therefore, it became evident early in our work with barn driers that a better method of curing the hay crop would progress far more rapidly when an easier method of harvesting could be developed.

Fortunately several farmers were interested in trying barn hay driers along with the regular methods of making hay, and these farmers used harvesting equipment which represents most of the new and old machines in use today. Three farmers used the buck rake and a wind stacker from the rear of a threshing machine. Five of them used the pickup field harvester and the hay chopper blower at the barn. Six of them used the field pickup baler with the barn drier. Two of them used the hay loader and truck with the regular hay chopper blower at the barn. The remainder used the hay loader, wagon and hay fork. Each of these harvesting methods will be discussed in the light of its use with a barn hay drier.

This paper was presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at New York, November, 1945.

C. N. TURNER is project leader, Farm Electrification Council of New York State.

Buck Rake and Wind Stacker. Where the fields are near the barn, the buck rake and the wind stacker method requires the least capital investment, and the least labor, and is the cheapest method of putting hay on the drier. About the only handling of the hay is forking it into the blower hopper. The loading in the field is fast and easy, the travel from the field to the barn is fast, the unloading at the barn is only a matter of seconds, and the distribution in the mow can almost be forgotten. With fields ¼ mile away three men or two men and a boy can keep a steady flow of hay going into the barn at the rate of 2 to 3 tons per hour. The use of the stacker method also distributes the hay on the drier in such a way that the air flows through it more uniformly than when mowed away by hand from a hay fork and track. Farmers also report that the hay placed in the mow with the stacker comes out easier for feeding.

Field Harvester and Hay Chopper. This method eliminates loading in the field and reduces the trips to and from the field by taking large loads, but the load is not easily disposed of at the barn. To solve this, one farmer used a small motor-operated conveyor to unload the chopped hay from the wagon onto the blower feed table. The chopped hay can be evenly distributed over the drier for uniform air flow. The density of the chopped hay increases the power required by the fan to force air through the hay in drying, and the chopped hay must contain a lower moisture content than long hay when placed on the drier for best results. While chopping would normally increase the capacity of the mow, this does not always hold true with the present drier design because the total depth is limited to about 14 ft which is usually less than one might store field-cured chopped hay. Field-cured hay can always be placed on top of the mow-cured hay, if the barn structure will carry the added weight.

Since chopped hay lends itself to mechanical handling, many farmers would like to see the hay drier designed to cure a greater depth. Barn curing eliminates the two greatest objections to chopped

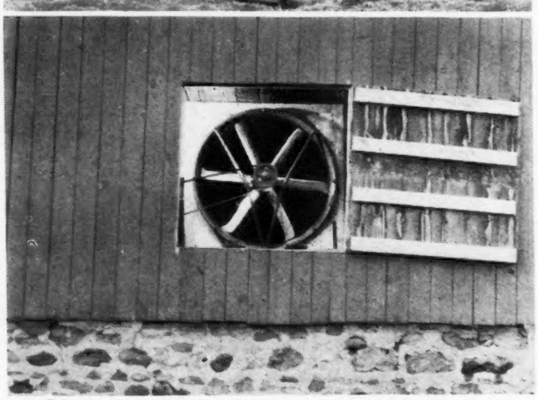
This picture shows the central main duct system for a barn hay drier in which the new type of baffled openings in the top of the main duct is used

hay harvesting, namely, dust and fire hazard. Both the fire hazard from dust ignition at the blower and the heating which causes spontaneous combustion in the mow apparently are eliminated when partially field-cured hay is finished on the drier. Chopped hay was cured very successfully on the driers this past year.

Pickup Baler and Conveyor. In the opinion of many authorities the field pickup baler is better adapted to the large farm than to the small farm. It has been used most economically on large farms where fields are far from the barn storage, where hay must be stored in one barn and moved to another barn for winter feeding, where hay may be offered for sale, and where the machine can be used to harvest the combined straw. A large crew is usually required; otherwise the baled hay is left in the field subject to considerable loss from sun bleaching, heating inside the bale, dew and rain. It is a rare thing when the custom-baling operation can be used successfully to put partially cured hay on the drier at the most satisfactory moisture content. Many requests have come to us from farmers who want to use a hay drier to keep the hay from heating in the bale after they have been forced to have it baled just a little too wet for safe storage. The hay drier may serve a useful purpose for this function alone in connection with the baled-hay method of harvesting.

A conveyor is usually required to assist in storing the bales on the drier. In a few instances the bales have been piled outside the barn and cured by forcing air inside the pile. The fan unit is portable and is moved from one pile to another.

The density of the baled hay is approximately the same as that of chopped hay and thus requires more power to force the air through the pile or layer than does long hay. Few pickup baling machines make a satisfactory loose bale and most of them are not built to handle hay containing over 25 per cent moisture. The slatted floor type of drier seems to be the best system adapted to drying baled hay. A depth of 7 to 8 ft seems to be satisfactory when the air delivery of the fan is at least 16 cfm per sq ft of mow floor against 1-in static pressure. The total depth of bales on the system should not exceed 12-14 ft.



Top: This view shows a field hay chopper used to place hay on a barn drier • *Center:* A wind stacker from a threshing machine is being used here to put 30 to 40 per cent moisture hay on a barn drier • *Bottom:* This is a 36-in propeller-type fan installed in a central main-duct system and driven by a 5-hp electric motor

Hay Loader, Truck and Hay Chopper. This method has the disadvantage of having to load the truck from the hay loader and unload by hand pitching into the hay chopper at the barn. Otherwise it is similar to the field harvester and hay chopper combination. Care must be used in setting up the chopper and distribution pipe to avoid plugging and to get good distribution of the hay over the drier. This method does not appear to have any advantage over the use of a wind stacker at the barn, except that the chopped hay handles easier from the mow to the feed alley.

Barn Hay Drier Observations. An additional 35 farms were added to the 15 hay drier installations included in our project in 1944. A total of approximately 2000 tons of hay was dried on these 50 farms during the 1945 season. All but two owners report that the hay cured on these driers is of better quality than their best field-cured hay. The two exceptions state that it seems to be about equal to their best field-cured product, but the drier insured this quality which could not always be obtained by field curing. These reports come to us as results obtained during one of the wettest and coldest seasons for many years. In some cases the hay that was cured on the drier was the only U. S. No. 1 hay which the farmer was able to harvest.

In partially curing the hay in the field prior to placing it on the drier, it is important to cure the windrow as uniformily as possible, otherwise the leaves on the outside will be lost, and at the same time there may be some wet bunches of hay inside which will cure too slowly in the mow. The average moisture content of the hay mass should not exceed 45 per cent for long hay or 35 per cent for chopped or baled hay. High moisture content often delays drying to the point where the hay turns yellow and white mold forms in the upper part of the layer.

In designing the installations this year the center and side main duct systems were most common. By tapering the main ducts the air flow approached a uniform velocity throughout the entire length. Cross sectional areas were recommended which gave main duct velocities of approximately 1500 fpm (feet per minute).

The air volume was based on 12 cfm (cubic feet per

minute) for each square foot of mow floor area to be delivered against ½ and ¾-in static pressure for long hay, and 16 cfm for each square foot of mow area against 1-in static pressure for chopped and baled hay. A few installations were designed with 18, 20 and as much as 30 cfm for each square foot of mow area to observe the possible benefits of more air. The 54 fan units fall in the following motor horsepower groupings: 27, 5 hp; 11, 3 hp; 6, 1½ hp; 6, 7½ hp, and 4, 2 hp. Propeller-type fans were recommended in all 1945 installations because of the flat horsepower curve characteristics under varying static pressure conditions. Repeated tests showed these fans to be loading the motors to within ½ to 1 amp of their nameplate rating. Centrifugal-type fans with forward curved blades overload the motors when starting to fill the mow and fail to deliver the required air flow as the mow became filled. The farmer had no way of knowing when the fan failed to deliver the required amount of air.

Without hay on the drier a typical installation using the 12 cfm per sq ft of mow floor area would have about 0.45-in static pressure in the main duct and about 0.10 to 0.20-in static pressure near the end of the lateral depending upon its length. The shorter laterals have higher static pressures because the outlet area at the floor is always less than for the longer lateral. Numerous tests of the systems before hay was placed in the mow showed a velocity at the 1-in opening in the ends of the laterals to range between 1600 and 2200 fpm, again depending upon the length of lateral. These velocities on any one system would vary about 300 fpm at the various laterals with the exception of the first one near the fan. The velocity from the first lateral was always lower than the others, and in some cases a scoop was placed in the air stream in the main duct to divert additional air into it.

WHAT CONTRIBUTES TO THE MORE SATISFACTORY OPERATION OF BARN HAY DRIERS

A few of the problems in connection with the more satisfactory operation of barn hay driers are as follows:

1 The problem of design and installation when left to the farm equipment dealer or the farmer should be given serious consideration by the manufacturer of the equipment and the electric power company selling the power, or unsatisfactory installations may result.

2 To make this problem easier, a straight main duct with the slatted-floor design may be of some help even though the first cost may be higher than for the tapered main and lateral-duct system.

3 The owner or operator of the system needs considerable education and experience in order to be able to get best results. He must learn to cut the hay at the proper stage of maturity in order to use the drying equipment to the best advantage, to cut only the acreage of hay which his crew can place on the drier in the following day, to judge the moisture content of the hay for ease of handling and curing, to distribute wet loads of hay carefully over the system to produce more uniform air flow, to tramp the hay lightly in corners and around posts where air is likely to escape, to avoid overloading the system by placing too much wet hay in the mow at one time, and to shut the fan off when the hay is cured.

In order to obtain a more accurate picture of how the barn driers were operated in 1945 and what the farmers actually thought about the method, a survey questionnaire was undertaken. To date 23 replies have been received and a summary of these replies follows:

The replies showed 834 tons of long, 520 tons of chopped and 40 tons of baled hay cured on these driers.

Twelve of the farmers cut their hay one day and put it on the drier the next. Nine of them put hay on the drier both the second and third days after it was cut. Three farmers put some hay on the drier the same day it was cut.

The average depth of hay put on the drier in one day was reported to be slightly over 5 ft, the range being from 1 to 10 ft.

Fifteen of the reports indicated that the fan was operated continuously day and night until the hay was dry. The remaining eight reported continuous operation for the early period of curing and either off entirely at night or on one hour at night by means of time-switch control.

All but four of the farmers reported that the barn-cured hay was better than their best field-cured hay. Their estimates of the increase in value averaged seven dollars with a range from three to ten dollars per ton over good field-cured hay. While all but four reported the quality better, only thirteen stated a definite value per ton. Two estimated the hay to be worth 50 per cent more. One who estimated a $10 increase in value stated that he put his best hay on the drier so that the entire price differential could not be attributed to the drying operation.

The last question asked whether the present method of barn curing was worth the extra labor and cost of operation to which all but two said "Yes", one stated that he didn't know, and the other said "No".

FURTHER HAY CURING STUDIES CAN BE JUSTIFIED ON THE BASIS OF THIS YEAR'S RESULTS

Based on the importance of a good quality hay to New York farmers and the favorable reports from those who have been through one or two seasons of hay drier experience, further hay harvesting and curing studies can certainly be justified.

In summary of the year's experiences the following conclusions seem reasonable:

1 A method of curing hay by forcing air through it in the mow is sure to be adopted in some form or another.

2 Farmers have expected too much of this system during this past year when especially difficult curing conditions existed. Some farmers placed 60 per cent moisture hay on the system and expected the drier to produce hay equal to that cured by a large commercial dehydrating plant.

3 The moisture content of the hay should be below 45 per cent for long hay and 35 per cent for chopped or baled hay in order to insure good quality on a barn hay drier using natural air. This is from the standpoint of harvesting equipment, manual labor in handling, the elimination of conditions which become favorable for mold growth and loss of green color.

4 Generally speaking, hay of the proper maturity cannot be as successfully cured when cut and placed on the drier the same day as when it is cut one day and placed on the drier the next. (Limited use of the "haymaker" which cuts and crushes the stems of the hay seems to indicate that the crop will dry enough faster on a good day to cut, crush and place on the drier during the same day.)

5 The hay should be more carefully distributed in the mow and should not be walked upon any more than is absolutely necessary. This is the reason that a better method of placing the hay in the mow should be thoroughly investigated.

6 The rate of air delivered by the fan for long hay can be 12 cfm per sq ft of mow floor for most installations where the farmer puts his hay on at the rate of 2 to 4 ft per day, but should be increased to the 15 to 18-cfm rate where he is equipped to put hay on the drier at the rate of 8 to 10 ft per day. This rate of air delivery should also be based on the moisture content of the hay when placed on the drier and also upon *(Continued on page 510)*

Industry Requirements of Professional Agricultural Engineering Education

AGRICULTURAL Engineers in industry are being penalized by the chaotic condition existing in schools preparing graduates for the profession. Among the colleges and universities offering curriculums in this field there exist seven different types of study programs. Engineers, who pride themselves on efficiency and a reasonable degree of standardization, are being prepared by an educational program lacking in those elements.

There is no desire for a hampering standardization, but this subcommittee believes that minimum educational requirements are essential to elevate the professional standing of graduates, to protect the reputations of educational institutions offering these curriculums, and to safeguard the interests of those industries dependent upon qualified graduate agricultural engineers.

Since the Subcommittee on Industry Requirements of A.S.A.E. Committee on Curriculums was appointed in 1941 numerous conferences and discussions have helped crystallize the thinking of the profession. A questionnaire was distributed by the subcommittee to all known agricultural engineering graduates in industry, soliciting their views of the most desirable, as well as the non-essential, of the subject-matter courses now being offered. The replies have focused attention not only on desirable subject-matter content of the curriculum, but also on certain over-all requirements. Again it is evident that the student frequently profits not so much by WHAT he is taught, as HOW.

It is the potential productive capacity of the individual which makes him employable. Efficient work habits, constructive thinking abilities, creative imagination, willingness to accept responsibility, pleasing personality and cooperative attitude are on a par with technical knowledge as essentials for most industrial employees. Those college faculties which inspire their students in personality and character building, assist them in attaining a high degree of technical enthusiasm, confidence and ability, and inculcate in them high standards of professional ethics and human understanding will be producing graduates of greatest value to industry.

The discussion which follows relates strictly to undergraduate professional curriculums. Service courses designed for students majoring in other fields or for subprofessional groups, and graduate courses giving the higher degree of specialization desired for professional research and education, are necessary and very desirable. They lie, however, beyond the field of our immediate interest.

GENERAL REQUIREMENTS OF PROFESSIONAL CURRICULUM

Certain administrative and environmental factors are desirable for conducting the professional curriculum in agricultural engineering. These may be listed as:

Report of the Subcommittee on Industrial Requirements, A.S.A.E. Committee on Curriculums (College Division), June, 1945

NOTE: This report is the result of four years of activity, 1941-1945, during which the following A.S.A.E. members served on the Subcommittee during all or part of the period: J. D. Long (chairman), agricultural engineer, Douglas Fir Plywood Assn.; Geo. R. Boyd, chief, farm products processing div., BPISAE, U. S. Department of Agriculture; L. J. Fletcher, director of training and community relations, Caterpillar Tractor Co.; L. F. Livingston, manager, extension div., E. I. du Pont de Nemours & Co., Howard Matson, chief, regional water conservation div., SCS, U. S. Department of Agriculture; W. R. Peterson, agricultural engineer, International Harvester Co.; Geo. A. Rietz, manager, farm industry div., General Electric Co.; A. W. Turner, chief, agricultural engineering divs., BPISAE, U. S. Department of Agriculture (formerly educational adviser, International Harvester Co.); I. D. Wood, engineer, SCS, U. S. Department of Agriculture; F. J. Zink, consulting agricultural engineer (formerly research engineer, Farm Equipment Institute.)

1 Curriculum to be 4-yr terminal engineering course.

2 Curriculum to be administered jointly by engineering and agricultural deans.

3 Department faculty, especially department heads, to be agricultural engineering graduates.

4 Suitable laboratory and shop facilities and equipment to be provided.

5 Graduate schools for specialization in one or more of the specialized technical agricultural engineering fields to be established where faculty and facilities warrant.

Four-Year Curriculum. It is essential that the curriculum be designed as an engineering course in every respect if agricultural engineers are to be adequately prepared for their responsibilities. Since high morale is essential to a profession, as to an army, this should be introduced in the student days by providing that agricultural engineering professional students are accepted on the campus as engineers. A four-year terminal course is believed preferable to a longer training period if students are to be attracted and held in sufficient numbers. At institutions where the other engineering curriculums have been extended to five years or more, it is logical that the agricultural engineering curriculum be similarly lengthened.

It is essential to the best interests of the profession that the college departments and their professional subject-matter courses be known as "agricultural engineering". Such professional subject-matter courses must comply in all respects with regard to prerequisites and course content with the standards set for other engineering subject-matter courses. The degree awarded for successful completion of the professional course should be "B.S. in Agricultural Engineering". The degree awarded a student matriculating in some other department, or in an institution not prepared to provide the essential engineering training should carry some non-competitive title, such as "B. S. in Agriculture; Major in Agricultural Mechanics".

Administration. In order that both fields of science be adequately represented in setting up the standards for the professional education program, course content, and faculty, and in providing the required financing for teaching and research, it is considered desirable for the agricultural engineering department to be administered and financed jointly by the deans of agriculture and engineering. Where this is not possible in its entirety, due to legislative or other definite restrictions, a close-working relationship should be established with both. Jealous guarding of prerogatives or past arrangements should not be permitted to prevent a fair and equitable cooperation between the two schools to this end.

Faculty. Since " a profession cannot rise above its educators", and since students are sensitive to professional origins, standards and enthusiasms, it is essential that the agricultural engineering department faculties, and especially the department heads, be agricultural engineering graduates. This will serve to develop in their students the highest degree of professional consciousness and loyalty.

It is not sufficient that these men merely know their subject matter. They must know how it fits into production on the farm or in industry. They must also know how to impart it to students; a reasonable knowledge and practice of good teaching methods is essential.

Two quotations from the graduate survey made by the subcommittee are of interest: "I doubt if there are many

courses which are not of some value. The problem is the determination of relative value, and the scheduling of those of greatest usefulness. . . . Then, too, the techniques and methods used in teaching a course are often of greater import than the subject matter." "I feel more concerned about the manner of teaching than I do about the subject taught. . . . . I still remember how inadequately prepared I was for mechanics and hydraulics after having passed the preliminary mathematics courses."

The proper selection of college faculties is a matter deserving even greater consideration than it receives. They should be men especially trained in developing the best type of human relations with their classes. From their performance the young engineer may learn by observation how to handle social as well as technical problems. In too many cases college faculties are employed and advanced because of their research ability, rather than their ability to work with people and to effectively inspire and teach. Personal introspection by the faculty members, and continued intradepartment discussions of teaching methods and problems are recommended.

Faculty members should be encouraged to participate in industry conferences, to accept summer and short-time employment in industry, to devote sabbatical leaves to industry surveys and employment, and to participate actively in the design and construction of practical agricultural projects. By so doing they can maintain close contact with the current and developing practices of the profession.

Facilities. Laboratory and shop courses, organized and conducted to teach principles and relationships rather than techniques, were stressed as highly desirable in the returns from the graduate-in-industry survey. Construction materials and their working characteristics, production cost accounting, and to some extent personnel relations can best be taught in such courses. Adequate laboratory and shop facilities and equipment are essential.

Graduate Schools. For most jobs in industry available to the young college graduate a thorough preparation in the fundamental sciences is to be preferred to a smattering of fundamentals and specialized knowledge. To prepare professional graduates for research, education and other highly specialized jobs in industry it is recommended that those educational institutions qualified by faculty, facilities and complementary departments establish graduate work in one or more of the various technical agricultural engineering fields of specialization. Advanced professional curriculums exert a noteworthy influence on both faculty and undergraduate students.

CURRICULUM COURSE CONTENT

Agricultural engineers-in-industry believe there are five major subject classifications which should be included in the undergraduate professional training program. These are (1) fundamental, (2) basic engineering, (3) basic agriculture, (4) social sciences, and (5) professional agricultural engineering subjects. Since graduates-in-industry are in general agreement that their responsibilities require a basic engineering training, this subject-matter field is stressed in these curriculum recommendations.

In the questionnaire returns from one technical group of agricultural engineering graduates it was interesting to note that only ten of the 66 subjects listed in the composite curriculum had been taken by all of those reporting. This indicates the serious lack of agreement currently evident among colleges as to the subjects which are essential to a sound agricultural engineering study program. It is obvious that industry must have a more uniform "product" if agricultural engineering graduates are to find a continued acceptance.

The agricultural engineering department faculty should be alert to the subject matter being taught in courses taken by their professional students in other departments, and tie agricultural engineering in to over-all scientific and production problems by influencing some consideration of agricultural engineering problems and potential contributions in those service courses. Subject-matter content and presentation must be such as to develop professional pride, creative thinking, a reasonable degree of productive ability and social consciousness, as well as to impart theoretical and technical information. With the increased agricultural engineering enrollments anticipated in the immediate postwar years it will frequently be desirable and practicable for other departments to set up special subject-matter courses for agricultural engineering students.

Fundamental. Courses in this category include mathematics, accounting, English, effective speech, journalism, physics, both inorganic and organic chemistry, botany, and biology. Three of these may have to be put on the options list, as indicated in the curriculum outline, in order to achieve a four-year terminal course.

It was surprising to find the number of graduate opinions which expressed dissatisfaction with the mathematics instruction they had received. Approximately 12 per cent struck at the traditional heart of engineering training by naming calculus on the list of unsatisfactory subjects. This is perhaps due to the courses being taught as abstract subjects rather than in a manner which would give practice in the practical application of mathematics to engineering.

Granted that mathematics is an essential engineering tool and an excellent educational training, it is suggested that serious consideration be given to "streamlining" the course content and teaching procedures. It may be possible to save some time spent ineffectively here in the curriculum for more desirable subject matter.

The content of each course, in mathematics as well as in other subject-matter fields, should be subjected to periodic critical review to delete impractical or obsolete material. This will permit the inclusion of current material, or of shortening the time devoted to the subject in favor of more important subject matter in other fields.

English and effective speech should be introduced early in the curriculum, and followed up by insisting on continued practice in other courses throughout the remaining 4 years. ("Almost every engineer we hire is woefully weak in spelling, English composition, and public speaking.") Both journalism and engineering reports are highly recommended as complements to the need of engineers in industry.

Physics and chemistry are obviously essential tools to an agricultural engineer. The desirability of adding organic chemistry to the usual requirements has been suggested by several graduates. Botany and biology are essential in a course which has been aptly called "biological engineering".

Basic Engineering. Drafting, descriptive geometry, materials testing and shop, analytical mechanics, surveying, electricity, thermodynamics, hydraulics, structural design and soil mechanics comprise this group.

Drafting is an essential "engineer's language". Course content should be modified to include freehand technical sketching, mechanical drafting practices representative of current industry practice, and simple pictorial representation.

Materials of construction including cast iron and steel, concrete and wood can best be taught in the shop and testing laboratory, provided these courses are brought up to date and conducted as engineering rather than manipulative skill courses. Graduates strongly favor reorganization and increased emphasis on this phase of the curriculum. The fundamentals of labor relations, materials specification and

production cost accounting can best be based on shop and laboratory experience.

Surveying, fundamentals of electricity, analytical mechanics, thermodynamics, hydraulics and structural design are basic engineering courses which are fundamental to agricultural engineering. Graduate opinion has indicated a need for reorganization of the work given in electric circuits and motors. Machine design and fundamentals of architecture are also necessary in one or more of the specialized agricultural engineering subject-matter fields, but may perhaps be postponed until the fifth year for graduate study. Soil mechanics, taught as a combination of physics and mechanics, is an essential course. It is possible that this should be one of the special courses for agricultural engineering majors, and should be conducted jointly by agricultural and engineering college faculties. Thermodynamics and hydraulics are both essential to many heat and fluid-flow problems which arise in all branches of agricultural engineering activity.

Basic Agriculture. Agricultural geology, soils and fertilizers, agronomy, domestic livestock types and physiology, and farm management offer a reasonable balance of agricultural subjects. It would be desirable to add dairy manufacturing and any other available food-processing courses.

Since soil is basic to agricultural production, it appears desirable to strengthen the agricultural engineer's study of this field by including geology, soils, and fertilizers as prerequisites to soil mechanics.

Agronomy and livestock types and physiology are essential subjects for professional men who are to be concerned with field production, storage, housing, processing, and utility problems. Several questionnaire returns gave favorable mention to feeds and feeding as desirable subject matter, presumably because of the insight such a course gives in biological processes.

Farm management is chiefly important in stimulating thought on the relative importance of different farm capital expenditures and operation techniques, and in giving fundamental concepts of time-and-motion study. Farm products processing courses may be expected to be of increasing interest to future agricultural engineering students.

Social Relations. Probably the best reason for including this group of studies is the statement, "In dealing with people it is not sufficient to be right, you must persuade." In the future, the engineer must deal with people to greater extent than in the past; liberalizing courses are more important for the undergraduate than specialized technical courses.

Included here are psychology, industrial economics, industrial administration, business and patent law, political science, history, and similar subjects.

Psychology, with special emphasis on salesmanship, has been suggested in the returns from graduates. ("Regardless of whether one enters commercial or academic work we are all salesmen in that we must sell ourselves and our wares to other people.")

It would appear that most institutions might well study the social relations program of the college of engineering of Carnegie Institute of Technology. This is a coordinated program extending through the 4 years, and offering the possibility of individual project study in the senior year.

Professional Agricultural Engineering. This group should start with a freshman survey and problems course for orientation, and include a junior-senior seminar. Reasons for the various subjects included in the curriculum, with emphasis on the fundamental sciences, should be presented in the freshman orientation course.

Required introductory courses should be offered in farm structures, field power, field machinery, soil and water conservation, rural electrification and farm utilities. Graduates voiced the criticism that these courses are frequently too elementary. Specialty courses other than these should be introduced in the undergraduate curriculum only where local conditions warrant. Provision for undergraduate specialization in one of the four major fields of agricultural engineering may well be omitted in favor of a more thorough grounding in the sciences.

Requiring at least three months practical experience in agriculture and a similar period in industry prior to graduation is recommended by several graduates.

Conclusions. The accompanying outline shows a possible grouping of the suggested subject-matter courses for each year of the four-year curriculum. Certain general college requirements such as physical education and military science have not been included. The required courses perhaps total more credit hours than are common to a four-year curriculum. One possible solution is the scheduling of shorter special courses in certain subjects, both in agriculture and engineering, and outlining the content especially for agricultural engineering majors. While this is contrary to the desire of most department administrators, it is a logical solution with the increased enrollments anticipated in this field.

SUGGESTED OUTLINE OF RECOMMENDED CURRICULUM IN AGRICULTURAL ENGINEERING

Year	Fundamental	Basic Engineering	Basic Agriculture	Social Science	Agricultural Engineering
First	Mathematics English Effective speech Chemistry	Drafting Descriptive geometry Materials	*Geology Soils	*History of man	Problems
Second	Mathematics *Chemistry Physics	Mechanics Surveying	Soil fertilizers	Psychology *Political science	Soil and water Power Machines
Third	Botany Biology *Journalism	Electricity Thermodynamics Hydraulics	Agronomy Livestock	Economics Administration	Seminar Structures Electrification
Fourth	*Accounting	Structural design Soil mechanics	*Farm management *Processing	Business law *Salesmanship	Farm utilities Seminar

* Suggested options

As suggested earlier in this report the agricultural engineering faculty should cooperate with other subject-matter faculties in having agricultural engineering reference material and problems introduced in service courses offered by the other departments. It is well for agricultural engineering students to secure in common classes the viewpoints of students majoring in other professions, but they should be privileged in turn to subject such classes to their professional problems. The attitude that service courses are too brief to impart fundamental knowledge and concepts in a subject-matter field and are a nuisance to teach should be avoided; they should be recognized as an opportunity to broaden the field of influence of each subject-matter department. It may be desirable to arrange conferences with the faculties of other departments to discuss the needs of agricultural engineering students, and to sponsor inspection trips for the service course faculty members to pertinent industries.

It may be well to re-emphasize that every man is self-taught, whether he spends his early adult years in a logging camp or exposed to the accelerated rate-of-learning program of a college. His thinking and actions are very largely influenced by those with whom he comes in contact. It is essential, therefore, that college faculties should not only have both practical and theoretical understanding in their chosen fields, and be sensitive to changing agricultural and industrial requirements, but should be able also to inspire in their students a sincere professional interest.

The Structural Application of Glue in Framing Farm Buildings (PART II)

By Henry Giese and S. Milton Henderson
FELLOW A.S.A.E. MEMBER A.S.A.E.

AS INDICATED in Part I of this paper[5]*, glue has been used successfully as a fastening medium in many farm buildings. Laminated rafters [6,7,9,10,15,17] and various rigid frame designs [1,5,8,12,13,14] are examples of the many conceived possibilities of increased effectiveness to be gained by the use of glue. Individual glued joints are much stronger and stiffer than conventional nailed joints of similar area and shape. A small amount of glue used on braces and gussets permits design of a type that minimizes material requirements and inside obstructions and at the same time produces a stronger and more durable building. Glued units too large to ship economically can be fabricated easily on the job by unskilled labor with ordinary carpenter tools.

High pressures, considered necessary in commercial fabrication, may be difficult to attain on the farm. Hence published strength and manufacturing data [2,11,16] may apply only to certain prefabrications such as curved laminated rafters. Joints made under limited pressure, such as that furnished by nails, have been considered potentially inferior to high-pressure joints. In farm building construction the use of clamps may be restricted by unavailability on scattered jobs and difficulties in application. If nails are used for holding the joint during curing, in many instances erection can take place immediately after assembly. This eliminates the curing period thus speeding construction.

The study reported in this paper was made to secure data which would apply to field assembled glued joints, the formal objectives being

1 To determine the strength of low-pressure casein glued joints held with nails only during the curing period.

2 To determine the durability of casein glue as used in farm structures.

3 To establish design loads for field glued joints.

All tests were made under shear loading which is typical of farm construction.

Casein glue was used exclusively because it is easily prepared, works well on moderately rough surfaces, is water resistant and not expensive.

Test specimens were made from Douglas fir, yellow pine and white pine as indicated in Figs. 1 and 2. No special preparation was given the surfaces to be joined except to insure cleanliness and moderate uniformity which were provided by selection rather than treatment. The casein glue, mixed as specified by the manufacturer, was applied to one surface and the parts nailed together with sevenpenny box nails. Specimens designated as B were mill fabricated under high pressure. Units B and C were sawed from laminated rafters which were made a few years ago for strength tests. Units A, D and E were made in sections two or three feet in length and sawed into shorter test units after curing. The method of nailing and cutting is indicated in Fig. 1. The tests were grouped according to the objectives (Table 1). Test units A, B and C (Fig. 1) were used to determine the shearing strength of glued joints for loading parallel to the wood grain. B and C were used for study of the effect of age upon strength. Samples D and E were used to determine the shearing strength for loads applied perpendicular to the grain. E was constructed as shown to eliminate the possibility of bearing failure of the wood affecting the results.

A standard Olsen testing machine of 20,000-lb capacity was used for testing. The shear samples were held in a jig

This paper was prepared expressly for AGRICULTURAL ENGINEERING. Contributed as Journal Paper No. J-1313 of the Iowa Agricultural Experiment Station, Project No. 23.

HENRY GIESE and S. MILTON HENDERSON are, respectively, research professor and research assistant professor, Iowa Agricultural Experiment Station.

* Superscript numbers refer to appended references.

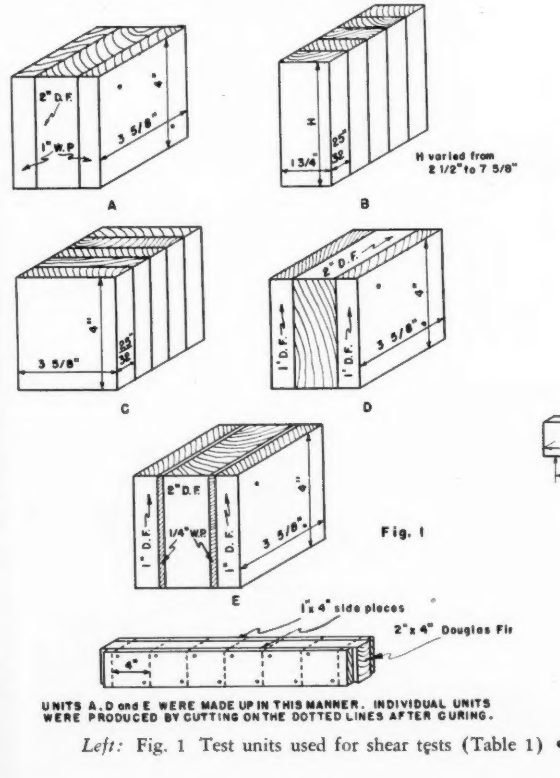


Fig. 1

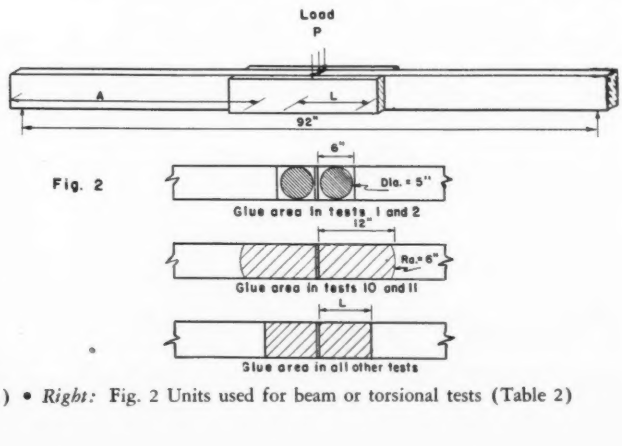


Fig. 2

Left: Fig. 1 Test units used for shear tests (Table 1) • *Right:* Fig. 2 Units used for beam or torsional tests (Table 2)

TABLE 1. SUMMARY OF SHEAR TESTS OF CASEIN GLUED JOINTS

Test No.	Factor studied	Wood‡	Test unit	Fastening	No. of tests	Curing time	Ult. Stress, psi Avg	Ult. Stress, psi Range	Type of failure
1	Joint strength	D.F. and W.P.	A	Nails	12	18 hr	929	1111-706	75% wood
2	and effect	"	"	"	12	3 da	915	1079-535	75% "
3	of fastening	"	"	"	12	10 da	926	1113-735	80% "
4		"	"	Clamps	10	10 da	926	1026-798	95% "
5		"	"	None*	10	10 da	527	772-121	30% "
6	Curing	"	"	Nails	12	18 hr	193	331-43	0% "
7	Conditions	"	"	"	12	3 da	747	1122-555	25% "
8		"	"	"	12	12 da	950	1172-681	50% "
9	Woods	D.F. and D.F.	"	"	24	7 da	763	1018-371	25% "
10		D.F. and Y.P.	"	"	24	7 da	1071	1496-723	35% "
11	Age	D.F. and D.F.	B	Clamps	19	8 yr	897	1220-660	95% "
12		Y.P. and Y.P.	C	Nails	19	13 yr	765	1292-151	35% "
13	Direction	D.F. and D.F.	D	"	12	23 da	443	548-278	85% "
14	of loading	D.F. and W.P.	E	"	10	7 da	421	504-338	85% "
15	Nails	D.F. and W.P.	A	Nails, no glue	12	3 da	37†		

*The glue was applied and the pieces stacked in place and pressed down with the hand to distribute the glue. No other pressure was used.

†262 lbs. per nail.

‡All tests except Nos. 6, 7, and 8 were made with lumber drier than 7 per cent and were cured at room temperature. Lumber for test Nos. 6, 7, and 8 was 11 per cent in moisture content and was cured at 50F.

(Fig. 3) which maintained alignment to be sure that the load was applied parallel to the glue line.

Characteristic failures are shown in Fig. 4. The light-colored areas indicate wood failure in pure shear. The darker areas show failure of stained wood close to the glue line. In B there is an area of glue failure at the top. In the darker lower portion of this picture, the failure is mostly in the wood although some glue failure appears in the region of the summer wood. This type of fracture is difficult to evaluate since the failure might be a combination of both wood and glue. A microscopic study of a number of failures indicated that those failures which, to the naked eye, appeared to be glue failure were actually partially wood failure. Small wood fibers had pulled loose from the wood surface. The softer spring wood bonded much better than the denser summer wood. However, the microscope showed that there was considerable fiber failure even in the dense summer wood. In spite of this difficulty, the estimates of type and amounts of failure are, in the main, significant.

The samples loaded parallel to the grain failed by horizontal shear in the wood or by pulling wood fibers away from the surface. The samples loaded perpendicular to the grain failed by pulling or "rolling" the fibers away from the surface.

Beams were made up with glued gusset plates to test glued joints in torsion in order to determine the applicability of the shear failure to such loading (Fig. 2). They were designed with sufficient length that horizontal shear did not affect failure. The glue was applied as in the shear tests and a minimum number of nails were used for holding (Table 2). Double-headed scaffolding nails were used.

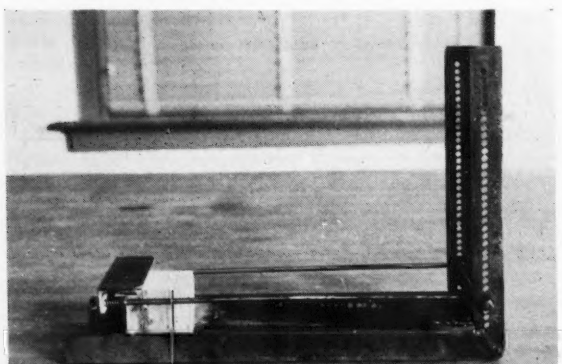


Fig. 3 Testing jig used with specimens 2, 4 and 5

These nails were pulled before testing so that the joint failure would not be affected by the nails. The method of failure of earlier tests made without pulling the nails was impossible to determine because glue failure would throw the load on the nails causing the gusset to split.

The maximum fiber stress was determined by the formula $S = MC/2I$, in which M is the moment at the center of the beam. I/C is the section modulus of one gusset.

The maximum shear in the glue was calculated by the formula $S = MC2/I$, M being the moment in the splice, that is, half the load or an end reaction times the moment arm L, I the polar moment of inertia about the center of the splice, and C the distance from the center of the splice to a corner.

Note that in the first six tests failure occurred in the glued joint under a maximum shear averaging a little over 400 lb per sq in. This value is comparable to that at failure for the shear joints loaded perpendicular to the grain (Table 1). The joints in the beams were stressed in the same manner. The joints with 12-in splices failed in the joint and in the extreme fibers of the gusset. Representative joint and gusset failures are shown in Fig. 5. The gussets failed when the splices were made longer than 12 in. The maximum fiber stress in the gusset for those units which failed in the gusset was very close to 8,800 lb per sq in, which is the modulus of rupture for white pine, natural individual variation being recognized (Table 2).

TABLE 2. SUMMARY OF TESTS OF SPLICED BEAMS (SEE FIG. 2)

Test No.	Length of Gusset Splice L, in	No. nails in splice	Maximum Load P, lb	Maximum Moment in joint, in - lb	Maximum Fiber stress in gusset psi	Maximum Shear in glue, psi	Type of failure
1	5 *	4	865	18600	2320	378	Glue line
2	5 *	4	1080	23200	3020	472	"
3	6	4	1835	39400	5125	576	"
4	6	4	1635	35100	4560	514	"
5	9	4	2390	49500	6590	478	"
6	9	4	2605	54000	7000	521	"
7	12	5	2050	41000	5725	225	Glue line in gusset
8	12	5	2660	53200	7425	237	"
9	12	8	2600	52000	7250	232	"
10	12 †	5	1880	37600	5250	206	Tension at knot
11	12 †	5	2965	59300	8260	326	Glue line
12	15	6	3160	60900	8825	215	Gusset
13	15	6	2380	45900	6650	162	"
14	18	6	3125	57900	8730	145	"
15	18	6	3980	73500	11100	184	
16	12 ‡	8	720	16600	2070		Nails pulled

*Glue area circular, 5 in in diameter

†Radius cut on gusset ends

‡Nailed only, no glue

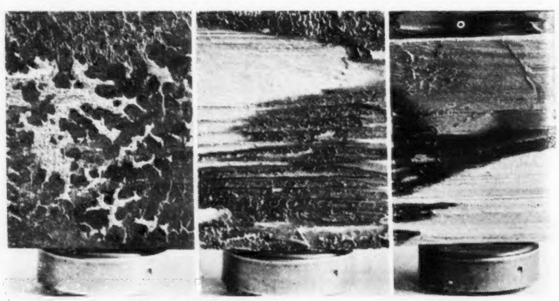


Fig. 4 Characteristic glued joint failures. *Left:* 100 per cent glue failure. *Center:* Only 20 per cent glue failure (top of sample and near bottom). *Right:* 100 per cent wood failure

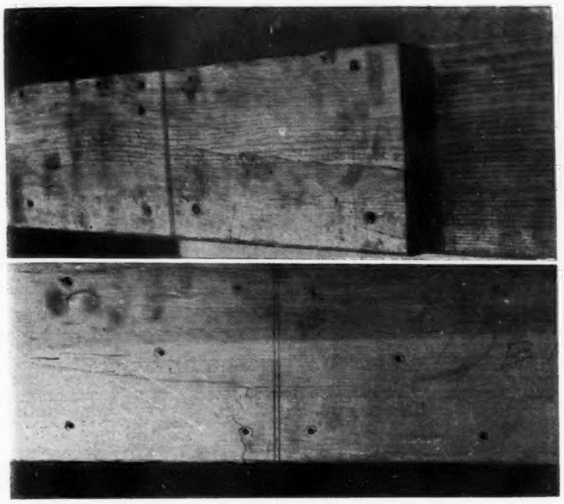


Fig. 5 Failure in beam tests. *Upper:* Joint failure. *Lower:* Tension failure in gusset

The ends of the gussets for tests 10 and 11 were cut to a radius to eliminate the corner-stress concentration and thus perhaps increase the joint strength. No improvement was indicated. These tests show that a glued gusset $5\frac{1}{2}$ in wide with a 12-in lap produces a joint stronger than the wood from which the joint is made.

Beam deformations were observed in Tests 8 and 16. The results are plotted in Fig. 6. The beams were unloaded for every 200-lb increment of load to observe the permanent set. Note the large permanent set observed for the nailed unit while no permanent set resulted in the glued unit. This demonstrates the relative strength and stiffness properties of glued versus unglued nailed joints.

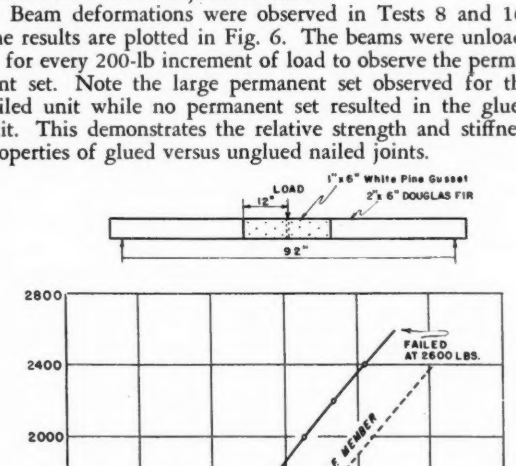


Fig. 6 The value of glue is demonstrated in these two tests. The glued unit received no permanent set during the entire test and performed similarly to a single Douglas fir member

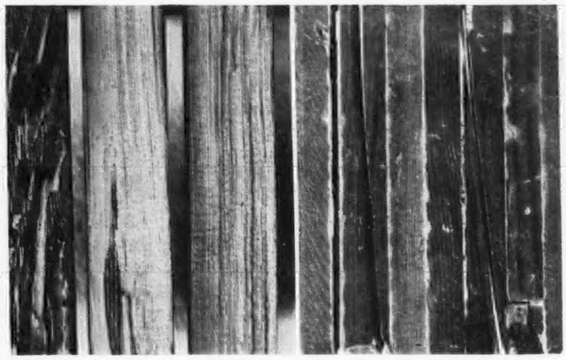


Fig. 7 Failures of glued laminated rafter 8 years old. Note that all the glued joints held, failure being shear in the wood.

Durability. Laminated rafters made by Giese and Anderson in 1931[6] were tested for shear strength (No. 12, Table 1). In making these rafters a strip about half the board width was coated with casein glue and the unit nailed together, no attempt being made to secure a perfect joint. These rafters were stored on a concrete floor in an unheated building with a leaky roof. This is probably a more humid condition than would be experienced in an actual installation with deterioration more probable. After 13 years these joints sheared at a load of 765 lb per sq in of glue area.

A glued laminated gothic rafter eight years old made under controlled factory conditions and stored under the same conditions as the rafter made by Anderson was tested (Test No. 11). A photograph of representative test samples is shown in Fig. 7. Note that the failures were pure shear in the wood rather than in the glue.

During the summer of 1936 Wilson[17] made a study of about 50 structures in Europe which employed glued, laminated construction, the structures varying in age up to 25 years. Relative to durability he made the following statement: ". . . . From experience to date it seems safe to assume that casein-glued laminated construction will last as long as solid wooden members of any but the more durable species of preservatively treated material. . . . " This statement, together with the test results discussed, indicate casein-glued construction to be durably satisfactory.

Design Suggestions. The range in variation in joint strength for each test series is tabulated in Table 1. This range indicates the probability of individual joints being either stronger or weaker than a joint represented by the average ultimate stress. If a single joint of critical strength is to be designed, it would be advisable to increase the joint area to compensate for any probability of low strength. However, farm construction is usually made up of a series of identical members all of which are similarly loaded with the probability of considerable transfer of loads from one unit to those adjacent to it. In this case the average ultimate stress could probably be used since low strength in one joint would be compensated for by superior strength of another joint.

In parallel loadings, the wood adjacent to the glue line is stressed parallel to the grain. The maximum shearing strength parallel to the grain for Douglas fir, yellow pine, and western white pine are 1140, 1370, and 850 lb per sq in, respectively. If a factor of safety of two is applied to the glued joints the design value will be 460 lb per sq in, a value which is below the minimum indicated in Table 1. This value would produce shear factors of safety of 2.5, 3.0, and 1.9, respectively, for the three woods under con-

sideration. Construction dead loads for farm buildings can be determined accurately. Live loads comprising grain, hay, livestock, machinery, water, and wind can be determined closely. In view of this, the customary high factor of safety for wood in farm construction is believed unnecessary. It is recommended, therefore, that 460 lb per sq in be used as a design stress for casein-glued joints loaded parallel to the wood grain for Douglas fir or yellow pine. A lower value, perhaps 400 lb per sq in, should be used for white pine.

Joints loaded perpendicular to the grain as well as the beam joints also perpendicularly loaded failed at an average value of about 430 lb per sq in. A factor of safety of two is suggested in this case, the design stress being 215 lb per sq in.

Spliced beams and other tortional members are recommended to be designed for 215 lb per sq in of glue area. The usual considerations must be given horizontal shear and stress in the outer fiber for both gussets and beam proper.

Because of the possibility of glue-line stresses being produced by warping, it is recommended that one of the members to be joined by glue be not over nominal one inch thick.

CONCLUSIONS

1 Casein glued joints cured by holding the surfaces together by nails failed at an average stress of 920 psi when loaded parallel to the grain, and at 430 psi for perpendicular loading.

2 Joints of lumber with moisture content of less than 7 per cent cured at 70 F reached maximum strength in 18 hr. Three days were required for 11 per cent lumber at 50 F.

3 Joints cured with no pressure were 60 per cent as strong as those nailed.

4 Douglas fir, yellow pine, and white pine all produced satisfactory joints.

5 Casein glue is of ample durability if protected from the direct action of water.

6 Design values for shear loading parallel and perpendicular to the grain of the wood are suggested as 430 and 215 psi, respectively.

REFERENCES

1 Crawford, F. M. Plywood brooder house construction. Unpublished thesis. Library, Iowa State College. 1939.

2 Dulac, Roger. Industrial Cold Adhesives. Chas. Griffin and Co., Ltd., London. 1937.

3 Fenton, F. C. Plywood for grain bin construction. Agr. Eng. 23:217-218, 222. 1942.

4 Forest Products Laboratory, USDA. Wood handbook. 1935.

5 Giese, Henry. The structural application of glue in framing farm buildings. Agr. Eng. 21:47-50. 1940.

6 Giese, Henry and Anderson, E. D. Tests of laminated bent rafters. Agr. Eng. 13:11-13. 1932.

7 Giese, Henry and Clark, E. F. Tests of laminated bent rafters (part II). Agr. Eng. 14:248-251. 1933.

8 Giese, Henry and Dunkelberg, G. H. Stressed plywood covering for brooder houses. Agr. Eng. 20:187-189, 194. 1939.

9 Martin, J. W. Elastic properties of glued, laminated rafter sections. Unpublished thesis. Library, Iowa State College. 1939.

10 Oates, W. J. The use of glued laminated rafters in farm buildings. Unpublished thesis. Library, Iowa State College. 1941.

11 Perry, T. D. Modern wood adhesives. Pitman Pub. Corp., New York. 1944.

12 Pickard, G. E. F. A study of the braced rafter roof. Unpublished thesis. Library, Iowa State College. 1935.

13 Rice, C. E. Analysis and design of a rigid frame gambrel barn roof. Unpublished thesis. Library, Iowa State College.

14 Stafford, Jr., J. P. Design and construction of plywood movable hog houses. Unpublished thesis. Iowa State College. 1940.

15 Test, W. D. Design of glued laminated bent rafter. Unpublished thesis. Library, Iowa State College. 1937.

16 Truax, T. R. The gluing of wood. USDA Dept. Bul. 1500. 1929.

17 Wilson, T. R. C. The glued laminated wooden arch. USDA Tech. Bul. No. 691. 1939.

Hay Harvesting and Storage

(Continued from page 503)

whether the entire mow area is equipped with the drying system or only a part of the area is so equipped since this will effect the rate of loading. The rate should be 16 to 20 cfm for chopped or baled hay.

7 The fan rating should be such that the above-stated delivery will be available against 3/4-in static pressure for long hay and 1-in static pressure for chopped or baled hay. The fan should also have a reasonably good delivery at 1-in static pressure for long hay and 1 1/4-in static pressure for chopped or baled hay even though designed for the lower pressure rating.

8 The fan should be operated continuously during the early stages of curing on the drier. Even a 4 to 6-hr interruption in fan operation when the hay is green may allow sufficient heating to cause the hay to become limp and settle into a compact mass which will prevent good air movement for satisfactory curing. After the first 5 to 7 days the fan can be operated on a time-switch control for one hour between 10:00 p.m. and 7:00 a.m. to save power during the final stages of curing a given layer. If small depths are placed on the drier each day, the common practice should be to run the fan continuously day and night until the hay is cured.

9 When no time switch is used a single-pole, single-throw switch should be used with a magnetic starter instead of the push-button momentary contact station. The single-pole switch will restore operation of the unit after a power interruption of short duration or momentary low-voltage conditions which may be caused by lightning storms. A manually operated knife-blade switch with delayed-action fuses for overload protection may also be used.

Following are some of the comments that were returned with the questionnaires on barn hay driers:

"Better than any field-cured hay this year; about equal to the best field-cured hay of other years."—C. E. Eldridge

"I consider the hay enough better so that I would be happy, if buying, to pay at least $5 extra per ton. I can see no extra labor in this method of handling the harvesting, but rather a saving if anything."—C. S. Gutermuth

"I am very well satisfied with this operation in general and think it will be even more satisfactory next year as we should know more about operating the equipment. The feeding value seems much better than hay from the same field not barn cured. In selling or using this hay I believe it would be worth 50 per cent more than field-cured hay, which on present basis of $20 hay would be $30 for this barn-cured hay."—D. C. Jeffrey

"I have learned that chopped hay can be put on flues to a depth of 14 feet or more if kept well spread and well packed around walls, posts, etc. The extra labor of leveling and the extra weight of greener hay is more than offest by less turning of windrows, chance of hay getting rained on and less dust in handling. There is no dust in chopped hay when pitching down in barn and feeding. This alone is worth all it costs. Cost of power about $1 per ton."—W. R. Reynolds

"All of the hay on our farms was baled. Besides the hay on the drier, as referred to in the questionnaire (30 tons), we had several tons baled in the lot which got rained on. We dried this and it came out perfectly. Last year we dried ten acres of pea beans. We pulled and drew them in the same day, in very misty weather. The beans came out very good; picked one pound per hundred."—Howard Van Derlike.

"From the time I started putting it in the barn I never stopped until it was all in. I never stopped to let any layers dry at all. But I did put some in the silo when it was just right. When too dry for the silo, I put it on the drier. If a load was dry enough for field-dried hay I put in the other end of the barn."—Donald Stacy

"As you know, I was very well pleased with the operation of the equipment and the method of drying hay. It was especially valuable during the past summer, due to frequent rains we had. It was often possible to save hay from being wet due to the use of the mow hay drier that would have been utterly impossible through field drying."—Thomas Wallis

The Direct-Expansion System for Cooling Milk on Dairy Farms

By R. L. Perry
MEMBER A.S.A.E.

IN THE direct-expansion system, milk is cooled by a surface cooler and stored until delivery in a dry reach-in or walk-in box. The lower, refrigerated section of the surface cooler is cooled directly by evaporating refrigerant within its tubes. The box temperature is held at about 40F (degrees Fahrenheit) by a tube and fin forced-convection evaporator.

Although the system has been used many years, it was not favorably regarded until about 1930, when adequate controls were developed to prevent freezing of milk on the cooler and to facilitate automatic operation. Since about 1935, the majority of new installations on all except the smallest dairies in California are of the direct-expansion type. The initial cost is usually lower than for a brine system, in spite of a slightly larger compressor size, because of elimination of the bulky brine tank and simplification of installation. The operating cost is lower because brine-tank heat absorption is avoided, and because of compressor operation at relatively high suction pressures. The troubles often associated with brine systems—adjustment of pump packing, make-up of brine volume and strength, and control of corrosion—have disappeared.

On a dairy farm near Davis, California, the brine system described by Moses and Tavernetti* was replaced by a direct-expansion system. The brine system, with a 4x4x7-ft cold box, operated by a ¾-hp air-cooled compressor, had a maximum capacity of 120 gal per day. It used 9.4 kw-hr per day in holding the box at 30F (lower than needed) and cooling an average of 73 gal per day. The new system, operated by a 1-hp air-cooled compressor, can cool 30 gal per hr. Operating 6 hr during the cooling of 150 gal of milk and running a short time in holding the box at 42F, it was using 6.4 kw-hr per day in April and is expected to average not over 8 kw-hr per day during the year. Thus it is using 15 per cent less energy and cooling nearly twice as much milk. In addition, considerable useful space is made available in the cold box by the removal of the brine tank.

In order to be successful, a direct-expansion unit must be of the proper size for the job. The cooler surface must be ample, else the temperature of the milk cannot be brought low enough, even if the surface temperatures approach the freezing point. The compressor must be large enough to handle the vapor as rapidly as it is formed, at a pressure low enough to secure prescribed milk temperatures. Too large a compressor is, however, undesirable, for it will operate much of the time at too low a pressure, with an energy consumption higher than necessary.

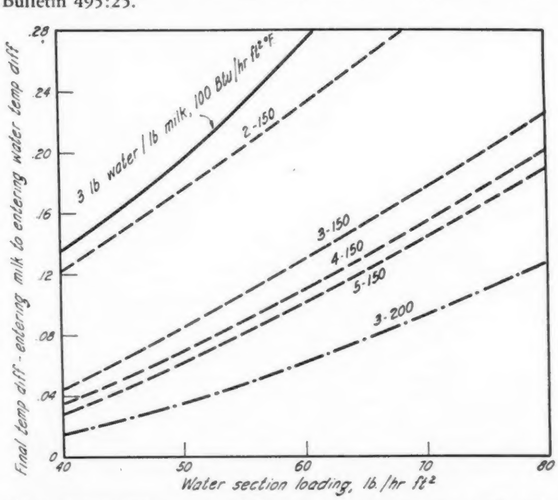
The compressor capacity is determined by the milk rate, and not, as in the brine system, by the total quantity produced daily. To cool one gallon per minute from 75 to 35 F, 320 Btu per min or 19,200 Btu per hr must be removed. The compressor must be able to handle this at a pressure corresponding to an evaporating temperature of 30F. (The evaporator surface temperature should be about 33F but some drop in pressure occurs in the cooler pressure-control valve and in the suction line.) The rating pressures should be 45, 28, and 20 lb per sq in gage at normal barometer for ammonia, freon and methyl chloride, respectively. The steps of stock sizes vary with different makes, but 19,200 Btu per hr can usually be handled at 30F by a 2-hp air-cooled machine in cool climates, or a 3-hp unit in hot regions. With a water-cooled condenser, a 1½ hp unit is usually adequate.

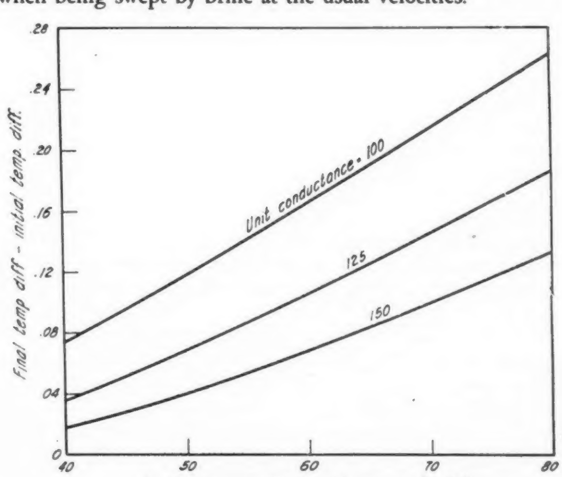
Surface-cooler ratings have not been standardized for direct expansion with low-pressure refrigerants. Somewhat more surface is required for direct expansion than for brine coolers, apparently because the unit conductance of the internal surface is poorer when evaporating refrigerant than when being swept by brine at the usual velocities.

This paper, now completely revised and brought up to date, was originally presented at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn., June, 1941.

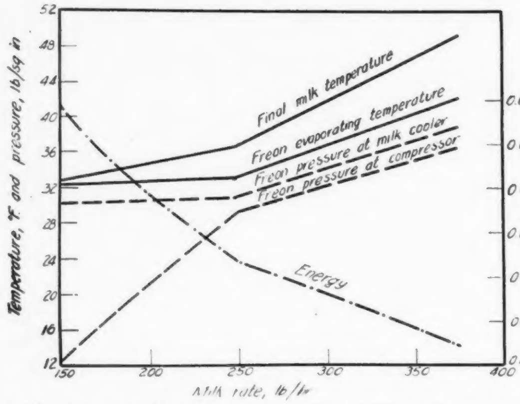
R. L. PERRY is associate professor of agricultural engineering, University of California.

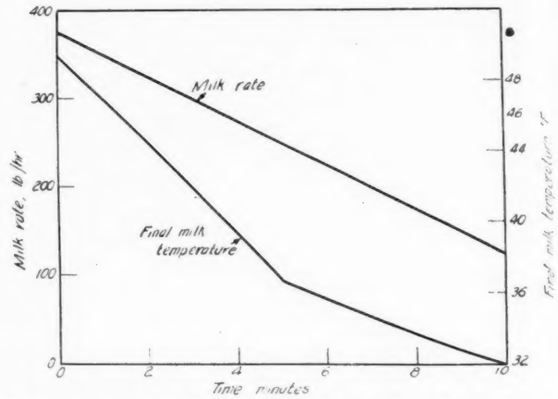
*Moses, B. D., and Tavernetti, J. R. "Milk Cooling on California Dairy Farms", California Agricultural Experiment Station Bulletin 495:25.





Left: Fig. 1 Performance of the water-cooled section of the surface cooler • *Right:* Fig. 2 Performance of the direct-expansion section of the surface cooler.





Left: Fig. 3 Final milk temperatures, refrigerant conditions, and energy required per gallon of milk, as influenced by milk rate, for a cooler designed to be operated at 250 lb of milk her hour • *Right:* Fig. 4 Change in milk rate and final milk temperature with time, as milk level falls in receiving vat

The unit resistance from the milk to the surface depends upon the viscosity and other thermal properties, the rate of flow in pounds per hour per foot of cooler width, the cooler height and tube size. An average value for milk under the conditions of dairy farm cooling is 0.004F/(Btu/hr ft²).

The unit resistance of the inside surface of the tubes in the water section depends on the tube diameter, water velocity, and water viscosity, which is a function of water temperature. Values of inside film resistance from Appendix C, over-all resistance, and over-all unit conductance (the reciprocal of unit resistance) are given in Table 1 for an average water temperature of 70F.

TABLE 1. THERMAL RESISTANCE AND CONDUCTANCE OF WATER SECTION

Water rate, gpm	Water film resistance, deg F/(Btu/hr ft²) 1-in tubes	1½-in tubes	Over-all resistance, deg F/(Btu/hr ft²) 1-in tubes	1½-in tubes	Over-all conductance, Btu/hr ft² F 1-in tubes	1½-in tubes
0.5	0.0081	0.0182	0.0121	0.0222	83	45
1	0.0047	0.0106	0.0087	0.0146	115	68
2	0.0027	0.0061	0.0067	0.0101	150	95
5	0.0013	0.0028	0.0053	0.0068	190	147
10	0.0007	0.0016	0.0047	0.0056	210	179

It is usually wasteful to run more than 3 gal of water per gallon of milk in the water section. With small coolers, the water velocity may be so slow that heat transfer is poor, and liberal surface area must be provided. It can be seen from Table 1 that the over-all conductance with 1½-in tubes is much poorer than with 1-in tubes, except with water rates approaching 10 gpm.

The milk temperature leaving the water section is determined by the cooler loading, in pounds per hour per square foot of surface, the over-all unit conductance, the water-milk ratio, and the initial milk and water temperatures, as given in Appendix D. Values of the difference in temperature between the milk leaving and the water entering the water-cooled section, are shown as a fraction of the available difference between entering milk and entering water in Fig. 1.

The thermal resistance of the evaporating refrigerant receiving heat from the tube surface is not accurately known. It can be expected to vary with tube diameter, rate of flow, nature of flow, kind of refrigerant, density of vapor, and temperature difference. A few random tests indicate an average value of 0.005F/(Btu/hr ft²). With this refrigerant-film resistance, a negligible tube wall resistance, and a milk-film unit resistance of 0.004, the over-all unit resistance is 0.004 + 0.005, or 0.009. The unit corresponding conductance is 1/0.009, or 111 Btu/hr ft² F.

The final milk temperature is determined by the refrigerant temperature, the temperature of the milk leaving the water section, the cooler loading, and the unit conductance. Temperature difference ratios for the direct-expansion section are given in Fig. 2, as computed in Appendix B.

Final temperatures for milk being cooled at several rates of flow over a cooler 30 in wide, with 8 1-in tubes in each section, are shown in Fig. 3. These curves are based upon the data of Figs. 1 and 2. A compressor which would maintain the cooler evaporating temperature at 33F with a milk rate of 250 lb per hr was assumed. Above 250 lb per hr, the cooler evaporating temperature rises because, at the increased vapor-weight rate to the compressor, the evaporating pressure rises, but below 250 lb per hr a constant-back-pressure control valve prevents the temperature from dropping below the freezing point.

In rating coolers and compressors for dairy farm use, the fluctuations in milk rate which result from intermittent supply of milk to the cooler must be given considerable weight. The rate of milk flow from the outlet valve of the milk receiving or strainer vat is proportional to the square root of the height of the milk level. After the receiving vat is filled, the milk rate decreases uniformly with time un-

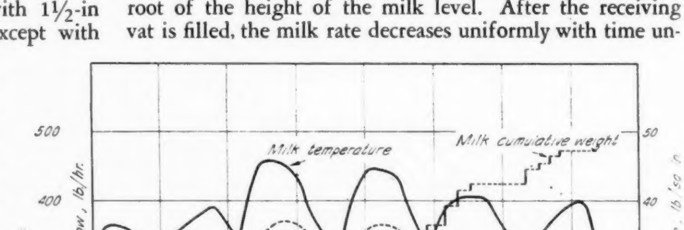


Fig. 5 Results of a test on a farm milk-cooling system

til more milk is added. Most of the milk flows at the more rapid rate when, as shown by Fig. 3, the milk is not so well cooled. For example, if the milk rate ranges from 375 to 125 lb per hr, as illustrated in Fig. 4, the average rate with respect to time being 250 lb per hr, the average milk temperature would be 40.1F instead of the 36.6F given in Fig. 2 for a uniform milk rate. If the rate ranged from 300 to 200 lb per hr, the average temperature would be 37.8F. In order to secure prescribed average milk temperatures with fluctuating rates, it is necessary to use a considerably larger cooler and compressor than indicated by the average rate. Part of the time the compressor then will be operating at reduced pressures, with higher energy consumption per gallon cooled.

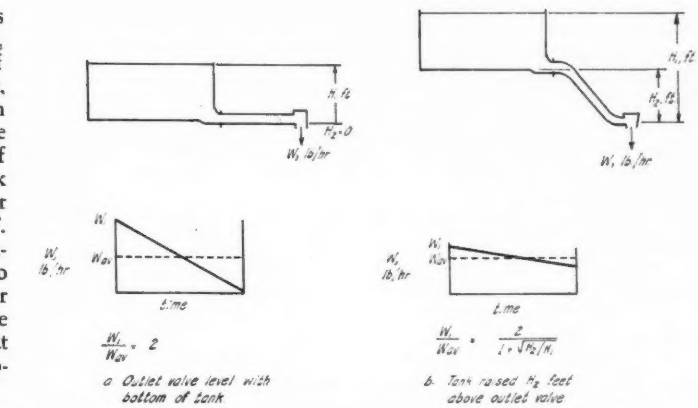


Fig. 6 Effect of raising the receiving vat above the outlet valve upon the fluctuation in rate of flow

Results of a farm milk-cooling test illustrating these points are given in Fig. 5. In this dairy 38 cows were milked in a barn with 12 stanchions. Two men did most of the milking, using three single-unit milkers. One other man milked part of the time, when not doing other chores. The cooler, 42 in wide, had eight 1-in tubes in each section. It was served by a 1½-hp freon compressor. Milk weight is shown cumulative with time; the milk-rate curve was estimated from the level in the receiving vat. The milk rate leaving the lower section does not fluctuate as rapidly as shown by the curve, because of the capacities and resistances to flow between the receiving-vat outlet and the bottom of the cooler. Change in pressure and temperature lag behind the milk rate because of the heat capacity of the cooler and refrigeration unit.

The average final milk temperature was 40F, and not the 38F indicated by the average of the temperature-time curve. The temperature of one can was 36F, while another was 44F. In an afternoon run, with high air temperatures at the condenser, the unit had less capacity and milk temperatures averaged 48F. It could have cooled the milk 3 to 4 deg lower if a steady flow had been maintained.

The milk rate can be kept more uniform by using a shallow receiving vat of relatively large area, with the outlet valve on a sanitary tubing line dropped several inches below the bottom of the vat, as shown in Fig. 6.

Freezing of milk, for which the direct-expansion cooler has been criticized, is easily prevented. When the milk rate decreases, the rate of refrigerant evaporation drops off. The compressor continues to pump about the same volume of gas, which, now containing fewer pounds, must be at a lower density and lower pressure. If the pressure in the cooler should decrease, the evaporating temperature would often fall below the freezing point of milk. To prevent the evaporating temperature from falling below the freezing point, a constant-back-pressure control valve is installed on the suction line between the cooler and the compressor. This valve allows vapor to pass from the cooler to the compressor only when the cooler pressure is above the set point of the valve, insuring that freezing does not occur. Some makes of valves do not have a sharp enough cutoff point, and offer too much restriction to flow when open.

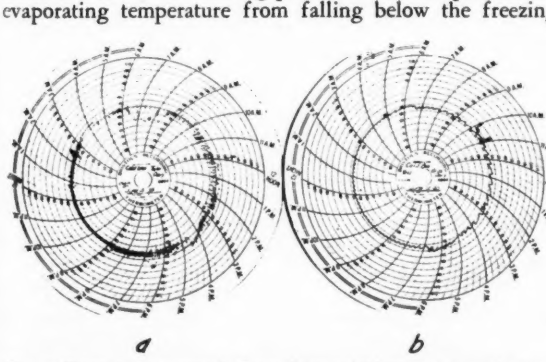


Fig. 7 Temperature records from dairy cold boxes, (a) with severe short cycling and (b) with satisfactory operation

A perplexing problem, which is not so readily solved, results from the difference in the refrigeration loads represented by the surface cooler and the evaporator in the cold box. The compressor must be large enough to handle the milk cooling load. It is then much larger than it should be for the box evaporator, which it serves between milking periods. For example, a dairy milking 90 gal in 3 hr has an average milk cooling load of about 9600 Btu per hr, and would require a compressor rated at 11600 Btu per hr to take care of peak rates of flow. A cold box large enough to store both milkings (sometimes a smaller box can be used if shipment is made directly after milking) will represent a load of only 900 Btu per hr during the summer.

Since the compressor has a capacity much greater than this, vapor will be removed from the cold-box evaporator much more rapidly than it forms, so that the pressure drops quickly and the low pressure switch acts to stop the unit. As the box warms up the coil, the pressure rises and the compressor runs again, possibly for only 15 sec. Under unfavorable conditions, extreme short-cycling occurs, resulting in severe service on the controls and on the starting mechanism of single-phase motors. Severe short-cycling is illustrated by the cold-box temperature record of Fig. 7(a). Better performance is recorded in Fig. 7(b).

Short-cycling is reduced by setting the low-pressure switch for a wide operating range. In some installations, cold-box evaporators larger than normal are installed, to adapt the vapor formation rate more nearly to compressor capacity. When this is done, it may be desirable to control the box temperature by a thermostat operating the coil fan, else wide low-pressure switch setting may give too low a box temperature.

Other possible solutions are as follows:

1 The installation of a surge drum on the low side, on a tee between the coil and compressor. When the compressor starts, it must pump down the surge drum as well as the coil, so that the pressure does not drop so rapidly, and a longer period results. After the compressor is stopped, part of the vapor evaporating from the coil can pass into the drum, so that refrigeration continues longer in the off period, and a longer off period results.

2 A throttling by-pass from the compressor discharge to the suction line, controlled by the suction pressure. This is not practical with the dairy-farm milk-cooling system, but is sometimes used where the smaller load is to be served only a small part of the time.

3 By-passes on one or more cylinders of multicylinder compressors. If a by-pass from discharge to suction line is used, there must be a check valve in the suction or discharge line of the by-passed cylinders.

4 Unloaders, which keep the discharge valves open on one or more cylinders.

5 A two-speed (1750-875 rpm) motor, controlled either manually or by a low-pressure actuated switch.

6 A two-speed transmission, or a double set of belt pulleys, to be adjusted before and after each milking.

7 A separate small compressor for the cold-box evaporator. This is probably the simplest and most troublefree solution.

SUMMARY

1 The direct-expansion system of milk cooling on dairy farms requires only one-half as much energy as the brine system, using 0.05 to 0.07 kw-hr per gal instead of 0.10 to 0.14 kw hr per gal.

2 At a steady rate of flow, a 1½-hp water-cooled compressor will handle one gallon per minute. For cooling one gallon per minute, an air-cooled compressor requires a 2-hp unit in a cool climate, or a 3-hp unit in a hot climate.

3 The water section of the surface cooler should have 10 sq ft of surface per gallon per minute, for loads up to ½ gal per minute. Above 1 gal per min, 9 sq ft per gal per min will serve.

4 The water section of the surface cooler should be built of 1-in tubes for milk loads less than 2½ gal per min.

5 In the direct-expansion section, 10 sq ft of surface per gal per minute should be provided.

6 Freezing on the cooler can be prevented by the use of a constant-back-pressure control valve.

7 Performance of the cooler is improved by operating at a relatively steady rate of milk flow. This obtains if the change in level in the strainer vat between successive additions of milk is less than half the height of the maximum level above the outlet valve.

8 For widely fluctuating rate of milk flow, 20 per cent more compressor capacity, and surface cooler are needed.

9 Energy consumption is a minimum when the compressor is run at the lowest speed at which the desired cooling is secured.

10 Since the refrigeration rate of the storage-box evaporator is only a fraction of that of the milk cooler, it is desirable to have some means of reducing the compressor capacity between milk-cooling periods, or to install a separate small compressor on the box evaporator.

APPENDIX A. *Nomenclature*

The following nomenclature, used in the appendices, is partially illustrated in Fig. 8:

A ft²	= area of surface
C_m Btu/(lb F)	= unit heat capacity of milk
C_w Btu/(lb F)	= unit heat capacity of water
D inches	= inside diameter of water section tubes
e	= base of Naperian logarithms
G gpm	= water rate
h Btu/(hr ft² F)	= surface unit thermal conductance
r F/(Btu/hr ft²)	= surface unit thermal resistance
t F	= Fahrenheit temperature. (See Fig. 8 for designation of subscripts)
U_w Btu/(hr ft² F)	= over-all unit conductance, water-cooled section
U_r Btu/(hr ft² F)	= over-all unit conductance, direct-expansion refrigerated section
V ft/sec	= average velocity of water in tubes of water section
W_m lb/hr	= milk rate
W_w lb/hr	= water rate

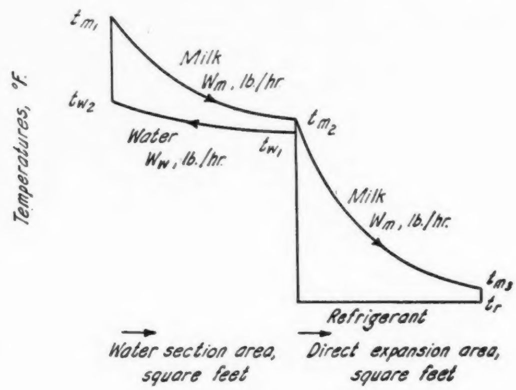


Fig. 8 Nomenclature

APPENDIX B. *Difference in Temperature Between the Milk Leaving and the Refrigerant Within the Direct-Expansion Section*

For general use, it is desirable to express the difference in temperature between the milk leaving, and the refrigerant within the direct-expansion section as a fraction of the difference between the milk entering and the refrigerant within the section, as follows:

$$\frac{t_{m3} - t_r}{t_{m2} - t_r} = e^{-\left(\frac{U_r A_r}{c_m W_m}\right)}$$

APPENDIX C. *Resistance to Transfer of Heat from the Milk Cooler Tubes to the Water Flowing in the Water-Cooled Section*

Resistance to heat transfer between a fluid and a solid boundary can be predicted for certain idealized cases by the momentum transfer analogy of Boelter, Martinelli and Jonassen†. However, for the particular problem of water flowing through surface cooler tubes, where the effect of the return bends is not accurately known, it is probably not worthwhile to go beyond the simplified empirical expression of McAdams‡,

$$h = \frac{150\ (1 + 0.011t)\ V^{1.8}}{D^{0.2}}$$

Since heat transfer in the surface cooler involves resistances in series, it is convenient to predict unit resistances instead of conductances. It is also simpler to use the rate of flow, in gallons per minute, instead of the velocity, taking into consideration the cross-sectional area of the tubes. Some laboratory tests indicate that the conductance in the small farm surface coolers is about 33 per cent greater than given by the equation above, because of the increased turbulence due to the return bends. Thus

$$r = \frac{0.01\ D^{1.8}}{(1 + 0.01t)\ G^{0.8}}$$

†Boelter, L.M.K., R. C. Martinelli, and Finn Jonassen. "Remarks on the Analogy between Heat Transfer and Momentum Transfer." Trans. A.S.M.E. Vol. 63, no. 5, pp. 447-455, July, 1941.

‡McAdams, W. H. "Heat Transmission." ed. 2, p. 183. McGraw-Hill Book Co. 1942.

APPENDIX D. *Difference in Temperature Between the Milk Leaving and the Water Entering the Water-Cooled Section*

For general use, it is desirable to present the difference in temperature between the milk leaving and the water entering the surface cooler as a fraction of the difference in temperature between the milk entering and the water entering, as given in Fig. 1. The relationship is complicated by the fact that the water passing through the tubes is warmed by the milk, so that the ratio of water to milk enters into the equation, as follows:

$$\frac{t_{m2} - t_{w1}}{(t_{m1} - t_{m2})\left(1 - \dfrac{c_m W_m}{c_w W_w}\right) + (t_{m2} - t_{w1})} = e^{-\left[\frac{U_w A_w}{c_m W_m}\left(1 - \frac{c_m W_m}{c_w W_w}\right)\right]}$$

The appearance of the term $(t_{m2} - t_{w1})$ in the denominator as well as in the numerator in the preceding equation is not so disconcerting as seems at first glance, for when the water rate is extremely high, the factor $\left(1 - \dfrac{c_m W_m}{c_w W_w}\right)$ becomes 1, and the denominator becomes $(t_{m1} - t_{w1})$. The equation is left in this implicit form so that its relationship to the equation in Appendix B can be readily seen.

Accreditation of Agricultural Engineering Curriculums

IN A letter to the Secretary of the American Society of Agricultural Engineers which appeared in the Society "Newsletter" for September, F. C. Fenton, chairman of the A.S.A.E. Committee on Curriculums, raised the question as to whether or not the Society should set up its own agency for accrediting agricultural engineering departments of the land-grant colleges and universities which offered professional curriculums leading to a degree in agricultural engineering or the equivalent thereof. Two interesting and constructive replies were received, and they are reproduced here for the information of agricultural engineers generally.

The first of these is a letter which Dean Roy M. Green, college of engineering, University of Nebraska, addressed to E. E. Brackett, chairman of the agricultural engineering department of that institution, and reads as follows:

"I wish to make some personal comments concerning the accrediting suggestion, if I might be permitted to do so. From my point of view I doubt the wisdom of your society entering into this activity as has been suggested, for two reasons:

"First, I am very much aware of the multiplying numbers of accrediting agencies and the disturbances and expense they cause to an administrator such as a chancellor of a university. The Association of Land-Grant Colleges and Universities has a committee on accrediting of which Chancellor Boucher is a member. Recently there was an attempt on the part of the American Institute of Architects to take over the accrediting of architectural engineering from E.C.P.D. (Engineers' Council for Professional Development.) It was a move backward for engineering, and I know that the Institute's committee viewed it critically. It would be better for engineers in general to become more unified rather than more dispersed.

"Second, the agricultural engineer is having some difficulty in being recognized before state boards of registration, but there is very definite progress being made in that connection. Your society should know that the only official accrediting agency recognized by the National Council of State Boards of Engineering Examiners is the E.C.P.D. setup. I am firmly of the opinion that if you created your own organization you would not be recognized by the National Council, and it would be a step in the direction of making it more difficult for your graduates to become registered before state boards.

"Personally, I hope you have a real vigorous discussion of this and then decide you should continue to function under E.C.P.D.

"I observe that your society is not listed as a cooperating member of E.C.P.D., but I know its Committee on Engineering Curricula would be more than glad to receive recommendations for visiting members of the A. S. A. E. whenever any agricultural engineering curriculum is to be accredited. I say this because of the positive statement made by Chairman Prentice at the St. Louis meeting concerning architectural engineering, which you may recall."

The second reply is a letter from Deane G. Carter, professor of farm structures, University of Illinois, to the Secretary of the A.S.A.E., and reads as follows:

"It appears to me that the first step in agricultural engineering curriculum improvement should be through the A. S. A. E. 'Accrediting' is a fighting word in some universities, with all the regulations and control exerted by associations in law, business, medicine, and other professional fields. No doubt such regulation is necessary to assure professional competency in the wide range of universities offering curriculums.

"It is particularly important that we have criteria for curriculum standards in agricultural engineering, for the concept of what constitutes agricultural engineering covers a very wide range. There are 'majors' in agriculture where only the number of credit hours in named courses differentiates the course from any other curriculum in agriculture. In some instances many of these credits are in shop, carpentry, and manual arts; they may or may not have prerequisites of mathematics and the physical sciences.

"The degree in agricultural engineering is offered in colleges where the curriculum is a composite of courses from various divisions without a sufficient staff in agricultural engineering to develop the philosophy and concept of agricultural engineering as a profession.

"It is confusing, too, that the curriculum may be administered in agriculture, engineering, and jointly.

"A very definite service could be rendered if the American Society of Agricultural Engineers could outline a general statement of degree requirements and establish a series of guides to generally acceptable course sequences, bases for admission to graduate study, desirable facilities for teaching, and some goals for quality of staff.

"I think it would be most unfortunate if acceptability would impose strict standardization. It would not be necessary to have exactly similar courses in every institution. Our departments have a valuable connection with the agricultural experiment stations which must be maintained.

"The occasional courses where both engineers and agricultural students are admitted may be mutually beneficial in the principles of application of machines, structures, forces, or materials to production.

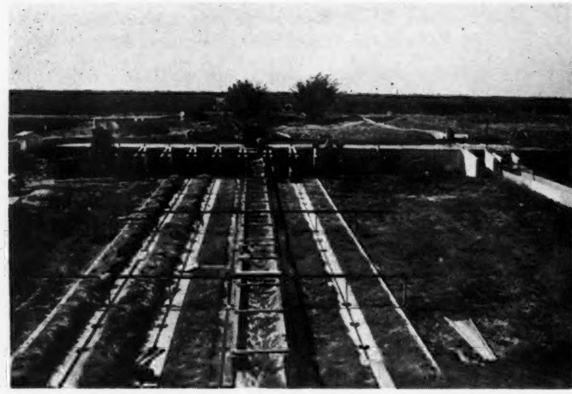
"On the other hand, there could be a general agreement that engineering deans should function to a considerable degree in the administration of the curriculum, that agricultural engineers should have essentially the same basic training as other engineering students, and that the courses in engineering design and theory should be identical with those in civil, mechanical, or electrical engineering departments.

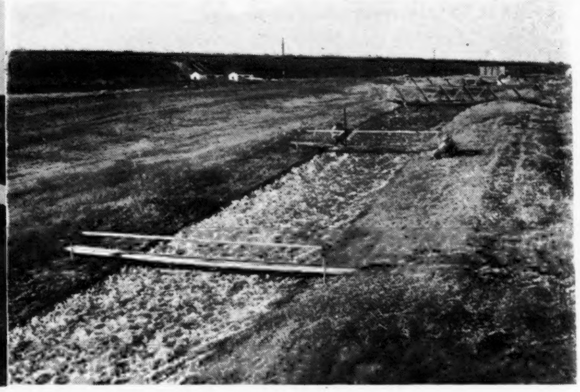
"Little would be gained by substituting A.S.A.E. accrediting for the E.C.P.D. Inevitably the agricultural engineers would face obstacles in state registration and professional associations. It is also likely that two classes of curriculums would develop, namely, A.S.A.E. approved and E.C.P.D. approved.

"Rather it seems to me that our society activity should be preliminary to the E.C.P.D., that is, to set our own house in order, to define the curriculum and the degree, and to set up the desirable elements of a professional course. In any event we would differentiate between the engineering degree and the major in agriculture, between the service courses and the professional courses, between the synthetic compilation of courses and organized sequences including sound agricultural engineering applications, and among the legitimate differences for specialization in soil and water conservation, farm structures, and power and machinery.

"A logical outcome of intensive work on our part would be the 'accrediting' by an accepted accrediting agency, perhaps without exhaustive detailed inspection and examination but upon the endorsement of the A. S. A. E. and the recommendation of the dean of engineering of the institution concerned.

"Committee work on curriculum revision was almost nonexistent during the war. It is likely that the postwar revision will incorporate more liberal arts or social studies and minimize the shop and handicraft subjects."





Left: Unit channels (rectangular shape with removable vertical walls) lined with weeping lovegrass and Bermuda grass tested for stability and capacity at the U. S. Soil Conservation Service (Stillwater, Okla.) hydraulic laboratory • *Right:* Testing a large trapezoidal-shaped channel at the Stillwater hydraulic laboratory with a flow of 74 cfs. The lining is Bermuda grass

A Method for Designing Vegetated Waterways

By Vernon J. Palmer

MANNING'S formula, $V = 1.486/n \times R^{2/3} \times S^{1/2}$, is now widely used in the design of open channels. Where n, the roughness coefficient, can be considered constant as with concrete, wood, etc., there are available numerous graphical, nomographic, and tabular solutions. Unfortunately these are not correctly adaptable to the design of vegetal-lined channels since the retardance (a more applicable term than roughness) offered to flow, changes markedly with depth and velocity. Vegetations are flexible in varying degrees; they oscillate in the flow, and their positions in the flow area change. The extreme variability of the retardance coefficient is illustrated in Fig. 1 for medium length Bermuda grass.

Flows through a vegetal-lined channel are logically divided into three types based on the hydraulic behavior of the lining. Refer again to Fig. 1. *Low* flows course between the stems and foliage without bending and sub-

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is a contribution from the Stillwater (Okla.) hydraulic laboratory of the U. S. Soil Conservation Service, Research Project OK-R-3, in cooperation with the Oklahoma Agricultural Experiment Station.

VERNON J. PALMER is acting project supervisor, Stillwater (Okla.) Hydraulic Laboratory, Soil Conservation Service, U. S. Department of Agriculture.

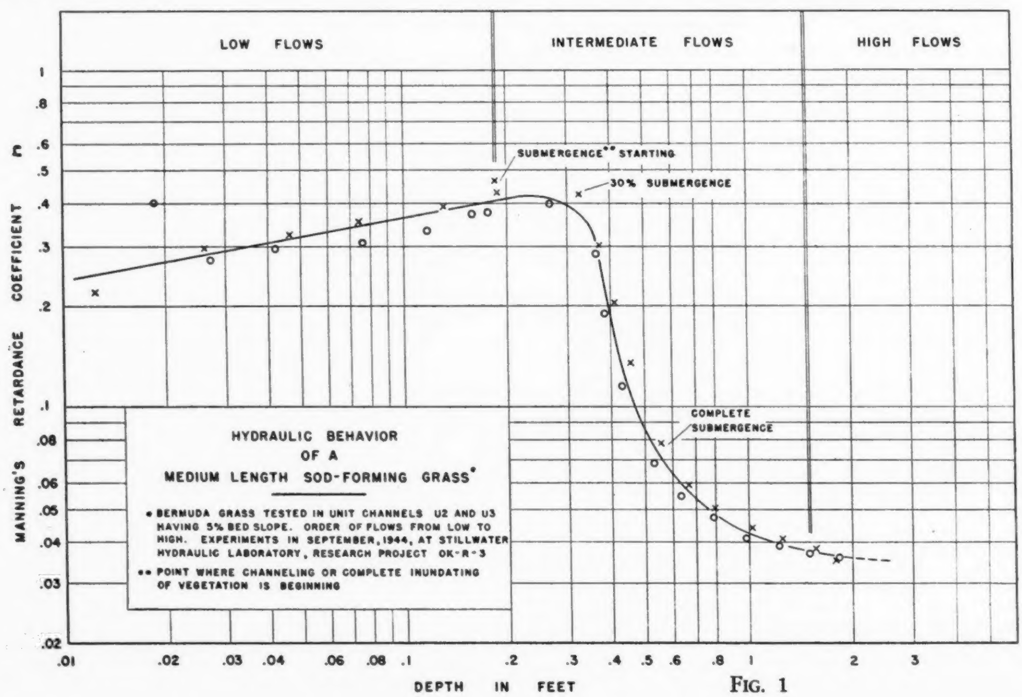


FIG. 1

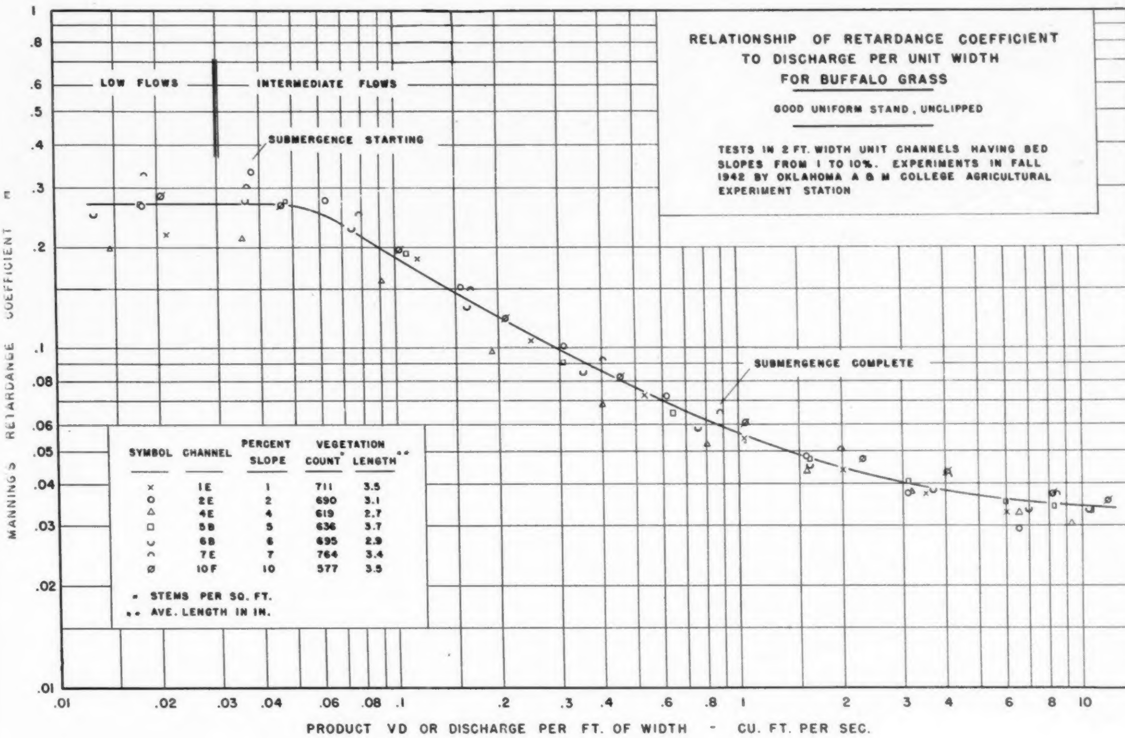


FIG. 2

merging them. A high, often constant, level of retardance coefficients prevails. *Intermediate* flows produce bending and complete submergence accompanied by a flattening of the vegetation towards the bed. In this range the

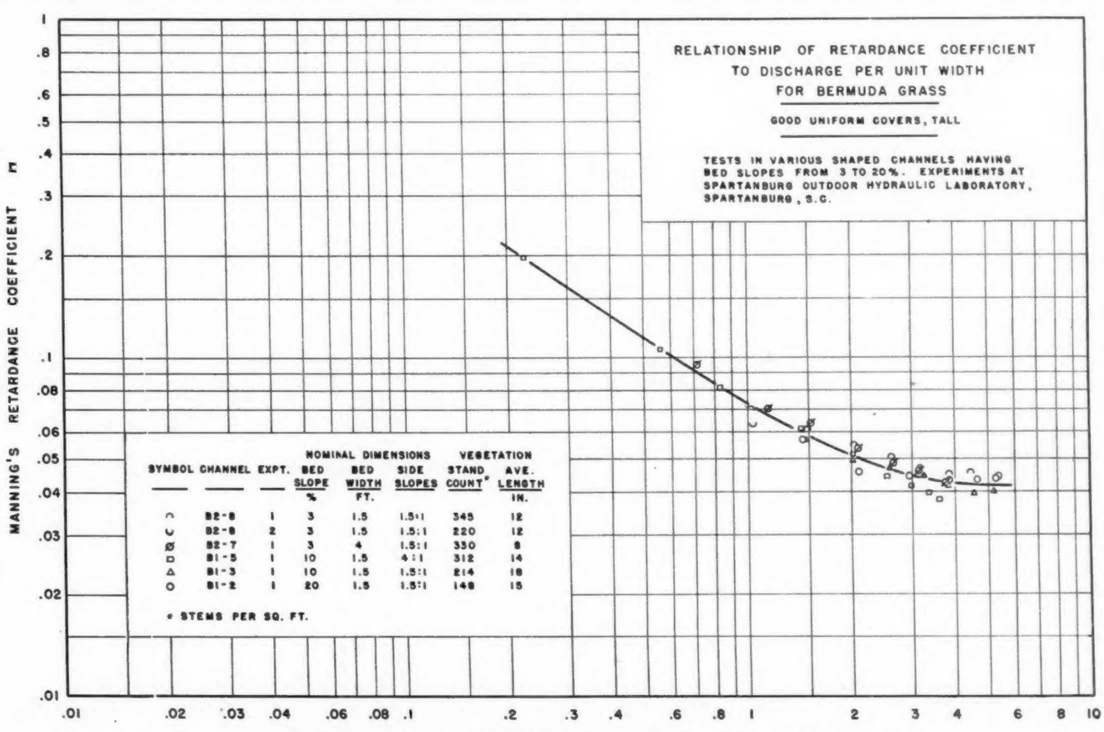


FIG. 3

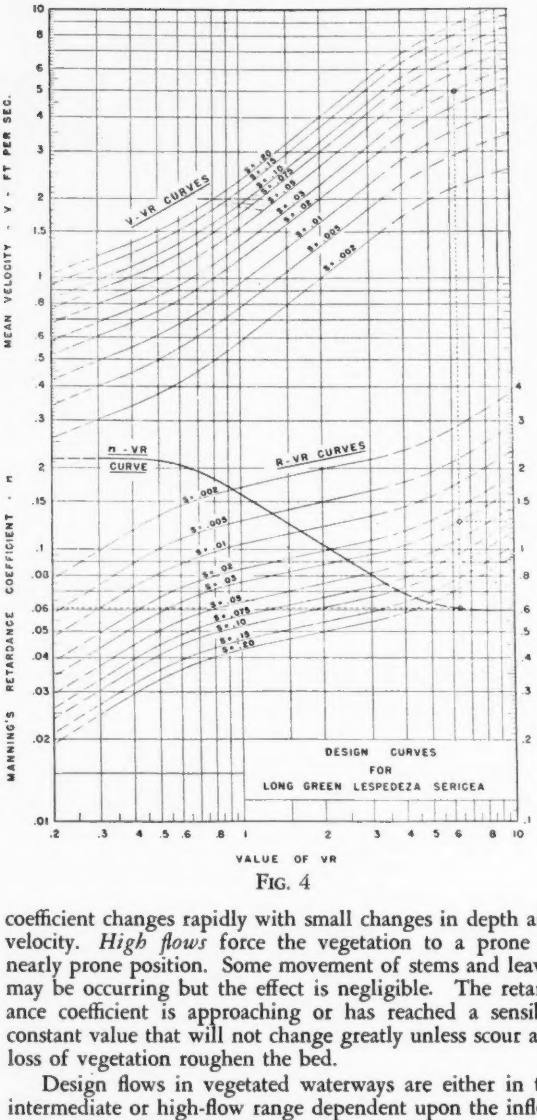


FIG. 4

coefficient changes rapidly with small changes in depth and velocity. *High flows* force the vegetation to a prone or nearly prone position. Some movement of stems and leaves may be occurring but the effect is negligible. The retardance coefficient is approaching or has reached a sensibly constant value that will not change greatly unless scour and loss of vegetation roughen the bed.

Design flows in vegetated waterways are either in the intermediate or high-flow range dependent upon the inflow discharge, the kind, flexibility and height of vegetation, and the bed slope. In terrace channels, terrace outlets, diversion channels and irrigation ditches lined with tall, rank vegetation the flow will generally be in the intermediate range. It is obvious that the application of a constant value of Manning's n would be particularly erroneous. It is only in the high-flow range that n can be considered constant but only dense sod-forming grasses like Bermuda grass and Kentucky bluegrass allow flows to extend into this range. With bunch grasses and covers like alfalfa, lespedeza, and kudzu, permissible velocities are usually exceeded before the high-flow range is entered.

A graphical method will be presented for designing vegetated waterways based on a variable n. It is developed from the results of channel experiments conducted by the Soil Conservation Service at Spartanburg, South Carolina[1,3,4*], and Stillwater, Oklahoma, and by the Oklahoma Agricultural Experiment Station[2]. The complete Spartanburg data and results including additional graphical solutions are to be published[4]. The material presented here is largely an extract of this future publication.

The retardance coefficient n is shown to be influenced greatly by the hydraulic behavior of the lining. This behavior for a vegetation in a specific condition is determined by the bending moment exerted by the flowing water. With this moment a function of depth and velocity it is reasonable to use their product as an indication of probable hydraulic behavior as expressed in the retardance coefficient n. Plottings of n versus VR (hydraulic radius R substituted for depth D since it represents average depth) have shown this product to be a good criterion for estimating n. Channel shape and bed slope appear satisfactorily accounted for as illustrated in the sample plottings in Figs. 2 and 3. It is interesting to note that this criterion, VR, or VD for very wide shallow channels, is the average discharge per unit width.

A correct design of a vegetal channel must have n selected so as to be compatible with VR. This is best accomplished with graphical solutions as in Figs. 4 and 5 developed from Spartanburg experimental data for long green Bermuda grass and lespedez sericea. An example of their use is as follows:

1 *Given:* $Q = 100$ cfs
$S = 0.03$ ft per ft

2 *Problem:* Determine the section of a channel that will have Bermuda grass for a lining. Consider a long green condition. Design for a maximum velocity of 5 fps.

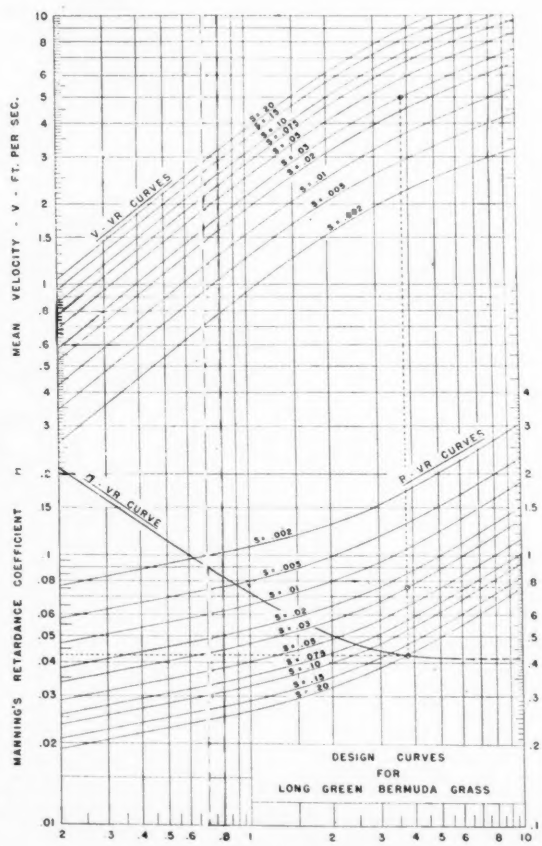


FIG. 5

*Superscript numbers refer to appended references.

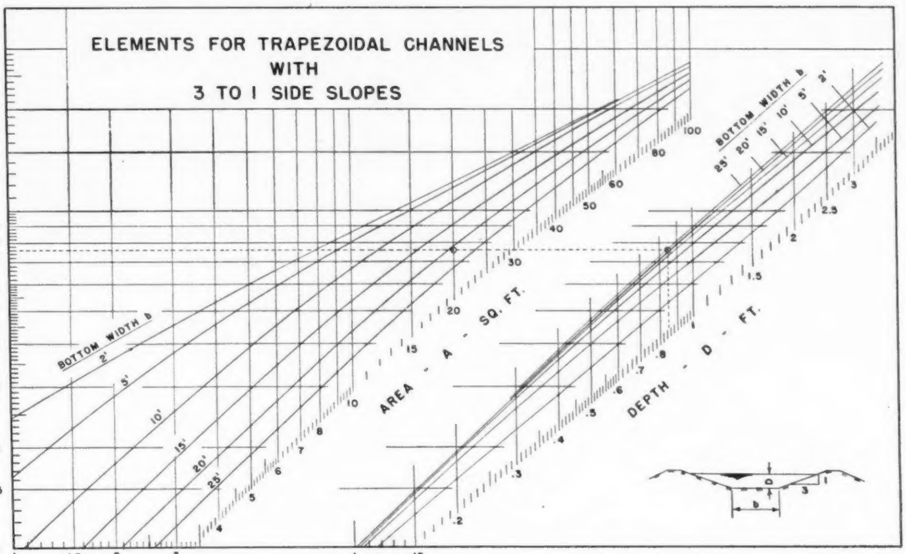


FIG. 6

3 *Solution for required R*: Enter the graph of Fig. 4 at $V = 5$, proceed right to the *(V-VR)* curve for $S = 0.03$, then downward to the *(R-VR)* curve for $S = 0.03$, then right to the R ordinate scale. This value of R, 0.76, must obtain for any section selected if the velocity is to be 5 fps. (It is not necessary to know n since its value is considered in the design curve placement. If desired, it can be secured by proceeding left from the intersection of the vertical dashed line with the *(n-VR)* curve to the n ordinate scale. In this example its value is 0.042.)

4 *Selection of channel section*: (a) Compute A since Q is known and V has been selected.

(b) Determine bottom width, side slope, or top width for a trapezoidal, triangular, or parabolic section (whichever shape is desired) by the intersection of R and A in the respective Figs. 6 to 9.

(c) Determine center depth, D, using these figures, by continuing right on the R line to the intersection with the sloping line for b, z or t.

Dashed lines in the channel-element continue the solution of the example where R was determined to be 0.76 ft. The area required is 20 sq ft. The channel sections meeting these requirements are as follows:

Channel shape	Side slope, z	Bottom width, b, ft	Center depth, D, ft	Top width, t, ft
Trapezoidal	3:1	21	.85	......
Trapezoidal	6:1	14	1.01	......
Triangular	8.5:1	......	1.53	......
Parabolic	....	......	1.16	26

Once R and A are known, any graphical or nomographic solution of various channels would be satisfactory. Those presented here are developed for utmost simplicity

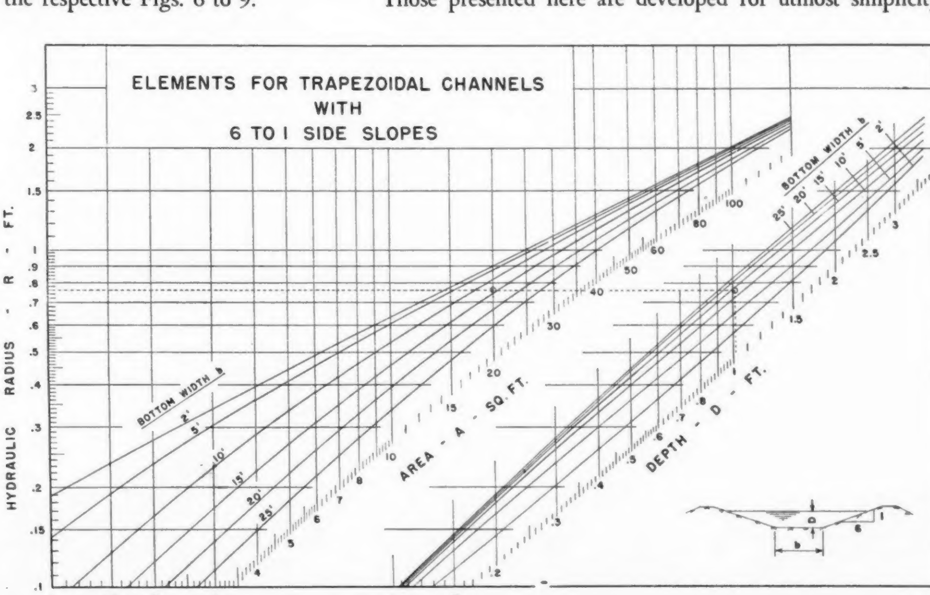


FIG. 7

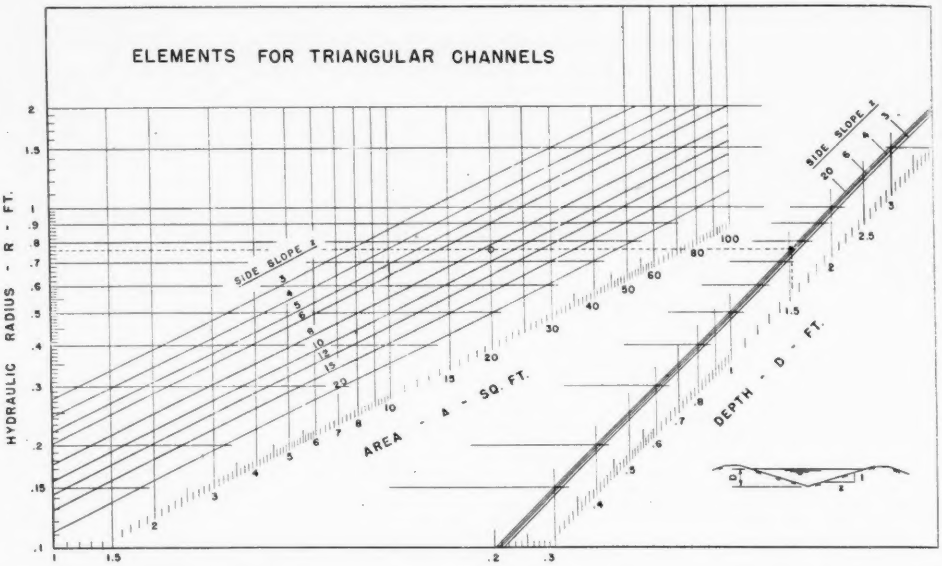


FIG. 8

in using the design curves.

The elements *b*, *z*, and *t* change rapidly with change in velocity. If the intersection of *R* and *A* does not lie within a graphical solution, investigate another shape or raise or lower the velocity and proceed as initially with a new *R* and *A*. A change in velocity of as little as 0.5 fps has considerable effect on the channel elements. Often a reselection of velocity will be desirable to secure a more favorable section.

The graphical solutions for Bermuda grass and lespedeza sericea serve a wide range of covers. The former is applicable to many medium-length sod-forming covers and the latter to many bunch grasses and tall, stiff-stalk vegetations.

REFERENCES

1 Cook, H. L. and Campbell, F. B., Characteristics of Some Meadow Strip Vegetations, AGRICULTURAL ENGINEERING, vol. 20, no. 9 (1939).

2 Cox, M. B., Tests on Vegetated Waterways, Okla. Agri. Expt. Sta. Tech. Bul. T-15 (1942).

3 Ramser, C. E., Grassed Waterways for Handling Runoff from Agricultural Areas, AGRICULTURAL ENGINEERING, vol. 24, no. 12 (1943).

4 Ree, W. O. and Palmer, V. J., Flow of Water in Small Channels Lined withh Vegetation (In process of publication as a USDA technical bulletin).

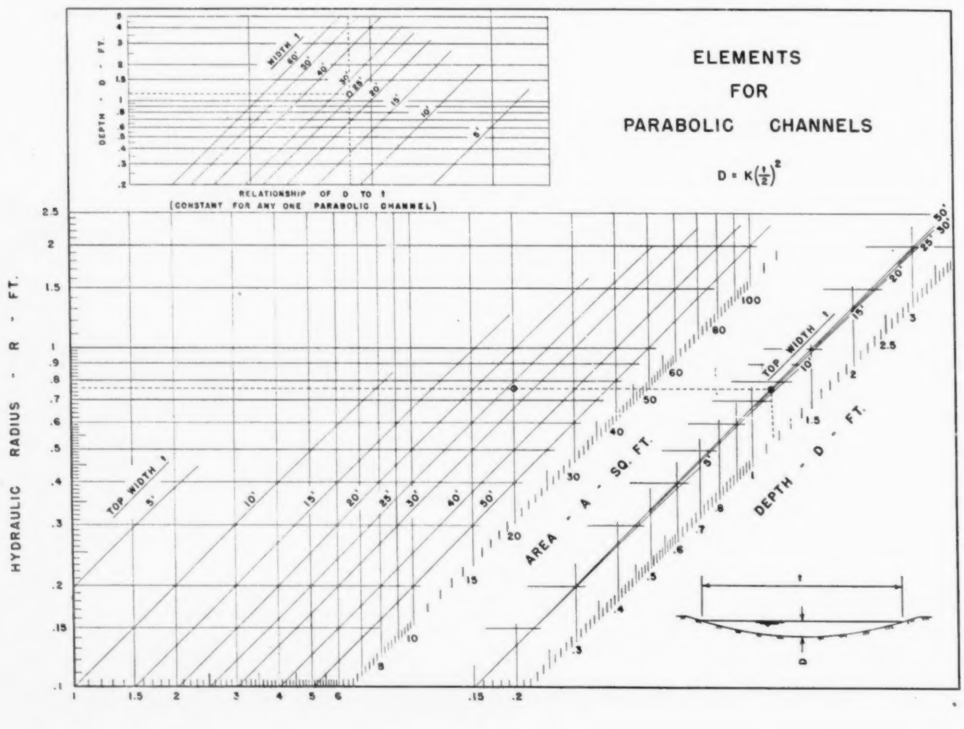


FIG. 9

NEWS SECTION

Barn Hay-Curing Conference

THE Committee on Hay Harvesting and Storage of the American Society of Agricultural Engineers, which is arranging the program for the Barn Hay-curing Conference being sponsored by the Society at Purdue University, Lafayette, Indiana, January 7 to 9, has announced a preliminary program for the conference.

The program for the forenoon of January 7 will include a paper on the nutritional value of forage plants by H. A. McDonald of the department of agronomy at Cornell University and an analysis of barn hay-curing failures as to rate of moisture removal by C. E. Frudden, consulting engineer of Allis-Chalmers Mfg. Co. It is expected that an additional paper on the principles of drying will be given at this session.

The afternoon program of the same day will include a paper on air flow through hay by C. K. Shedd, agricultural engineer of U. S. Department of Agriculture, and a paper on the conditions favorable to mold and spoilage in hay. The speaker on the latter subject has not yet been announced.

At the evening session of the first day there will be presented results of a survey on hay handling by M. R. Cooper, senior agricultural economist, U. S. Department of agriculture. A motion picture presentation on haymaking in the sand hills of Nebraska will be shown by L. F. Larsen. extension agricultural engineer for that state.

The program for the forenoon of January 8 will be opened with the subject of getting even distribution of air through hay which will be covered by three speakers, one on long hay, another on chopped hay, and a third on baled hay. Wayne W. Hudson, of Hudson Enterprises, will discuss the use of a chemical deterrent to heating, mold and spoilage in hay. Another topic will be an analysis of fan characteristics, speaker for which has not been announced.

At the afternoon program the same day, George R. Shier, consulting agricultural engineer, will present the paper on calculating fan, motor, and duct requirements. Another paper on air flow in ducts will be presented at this session, but the speaker has not yet been announced.

The program for the forenoon of January 9 will be devoted to a discussion of problems in handling damp hay, in which persons who have had experience with those problems in various parts of the country will participate. The afternoon period will be devoted to a round-table discussion of research problems in barn hay-curing by research workers.

All sessions of the conference will be held in the Purdue Memorial Union building on the Purdue University campus, and it is also expected that the Memorial Union and the Fowler Hotel in Lafayette will have guest rooms sufficient to house most of those who attend the conference. Request for guest room reservations should be made direct with the Union or Lafayette hotels.

The Purdue Memorial Union, in order to make its limited number of rooms as serviceable as possible for the conference will accept reservations for double occupancy only. However, comfortable cots will be added to rooms with one bed so that each person may have his own bed. Memorial Union rates for double occupancy are as follows: Twin bed rooms, \$5.00; rooms with cot added, \$4.75; parlor suites, \$8.00; suites of twin bed rooms with adjoining bedroom, \$9.00 (for four persons).

The Fowler Hotel offers the following types of rooms and prices: Single room with bath, \$2.75 and up; single room without bath, \$2.25; double room with bath, \$4.00 to \$5.50; twin bed room with bath, \$5.50 to \$6.00.

Reasonably good accommodations are also available at the Lahr Hotel in Lafayette.

Southeast Section Meets in February

THE Southeast Section of the American Society of Agricultural Engineers will hold its next meeting at the Thomas Jefferson Hotel in Birmingham, Alabama, February 13 and 14, 1946. An interesting and attractive program is being arranged for the occasion and will be announced shortly. Complete information about the meeting and copies of the program may be obtained from Section Secretary G. E. Henderson, 610 Arnstein Bldg., Knoxville, Tenn. All members of the Section, however, will have mailed to them copies of the program as soon as they are printed.

Pacific Coast Section Meets February 26

THE Pacific Coast Section of the American Society of Agricultural Engineers will hold its 29th annual meeting at Sacramento, Calif., February 26, 1946, according to announcement by Walter W. Weir, secretary-treasurer of the Section. Place of meeting and information on the program will be announced later.

Gillham Heads Tennessee Section

AT a meeting of the Tennessee Section of the American Society of Agricultural Engineers held at Knoxville on November 17, W. C. Gillham, associate agricultural engineer, Tennessee Valley Authority, was elected chairman for the ensuing year. M. T. Gowder, assistant extension agricultural engineer, University of Tennessee, was elected vice-chairman, and G. M. Petersen, associate professor of agricultural engineering, University of Tennessee, was re-elected secretary-treasurer of the Section.

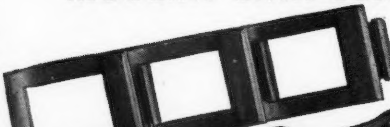
The principal speaker on the occasion of the meeting was S. P. Lyle, Extension Service, U. S. Department of Agriculture, who gave a most interesting and stimulating talk on the value of a professional organization such as A.S.A.E., with particular reference to the desirability of state sections. *(Continued on page 524)*

Part of the group of 65 persons attending the meeting of the A.S.A.E. Pennsylvania Section at State College on October 22 and 23. Front row, left to right: R. A. Knight, retiring Section chairman; E. W. Schroeder, Section secretary-treasurer; Paul J. Newton, new Section chairman; J. Dewey Long, president of the A.S.A.E.

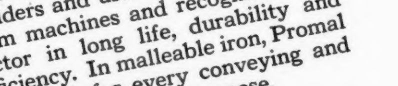
Latest model of NEW IDEA hay loader is an example of modern farm machinery using Link-Belt Chains.

MAKING HAY *the* NEW IDEA *Way!*

MODERN LINK-BELT CHAINS PROVIDE DEPENDABLE DRIVES



Link-Belt Chains are well-known by builders and users of many types of farm machines and recognized as a factor in long life, durability and efficiency. In malleable iron, Promal and steel, for every conveying and power-transmission purpose.



• Forage crops reach the market as meat, milk or fuel for "hayburning" horse power. In any case their importance in the over-all farm picture demands hay-making equipment as efficient and durable as any farm machinery today.

New Idea hay rakes and loaders, designed to provide dependable, trouble-free operation utilize modern, efficient Link-Belt chain for vital drive functions. These chains made by the pioneer and world's largest manufacturer, have been continually improved and developed, in keeping with the advances made in all types of machinery on which they provide positive, efficient drives and conveyors.

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Offices in principal cities.

10,015

LINK-BELT CHAINS

FOR DRIVES • FOR CONVEYORS • FOR POWER TRANSMISSION

NEWS SECTION

(Continued from page 522)

Georgia Section Officers

The Georgia Section of the American Society of Agricultural Engineers has new officers. They are as follows:

Chairman, Harold D. White, associate professor of agricultural engineering, University of Georgia; vice-chairman, J. H. Hudson, assistant soil conservationist, U. S. Soil Conservation Service; and secretary-treasurer, H. S. Glenn, rural electrification specialist, Georgia Agricultural Extension Service.

Zink Heads Chicago Section

AT a quarterly dinner meeting of the Chicago Section of the American Society of Agricultural Engineers held at the Builder's Club, Chicago, December 7, Frank J. Zink, head of the consulting firm of Frank J. Zink Associates, was elected chairman of the Section for the ensuing year, succeeding A. W. Farrall, formerly chief of research, Creamery Package Mfg. Co., and now head of the agricultural engineering department of Michigan State College. Other officers of the section elected were as follows: Vice-chairman, D. G. Womeldorff, Public Service Co. of Northern Illinois; second vice-chairman, H. C. Smith, Sisalkraft Co.; and secretary-treasurer, W. R. Peterson, agricultural engineer, International Harvester Co. The new nominating committee of the Section consists of E. I. Hansen, chairman, C. N. Hinkle and W. H. Lloyd.

The meeting, which coincided with the Fall Meeting of the parent society held the same day at the Stevens Hotel, was especially arranged for the benefit of A.S.A.E. members in Chicago for the latter meeting. Following the dinner, which was attended by 150 members and friends of the Society, a program was presented, the topic of which was "Engineering Farm Labor". The principal speaker for the occasion was Dr. E. C. Young, dean of the graduate school, Purdue University. Following Dr. Young's talk, a panel of experts answered questions submitted by those present, and at the conclusion the discussion was summarized by I. D. Mayer, agricultural engineer of the Indiana Agricultural Experiment Station.

A.S.A.E. Members Advisory to USDA Graduate School

IT may be news to many, but for twenty-five years the graduate school of the U. S. Department of Agriculture has been meeting the needs of government employees for advanced instruction, sometimes on the advice and request of supervisors, division directors, bureau chiefs, or other responsible persons, but very often at the direct request of employees themselves. About five years ago, committees in each department of instruction were established to make recommendations to the general administration board of the graduate school, one of which is the Departmental Committee on Engineering and Mechanical Arts, of which Dr. R. W. Trullinger (Fellow A.S.A.E.), assistant chief, Office of Experiment Stations, is a member. This committee having requested the appointment of an advisory committee representing national engineering societies for obtaining such advice and assistance as it may require from time to time, the director of the graduate school recently invited the Washington Section of the American Society of Agricultural Engineers to designate a representative to this advisory committee, and an announcement has just been made that the chairman of the Section, E. M. Dieffenbach, has appointed Arthur W. Turner, assistant chief of the Bureau of Plant Industry, Soils and Agricultural Engineering as the Section's representative, with Dr. M. L. Nichols, chief of research, Soil Conservation Service, as alternate.

NRSSP Material for Agricultural Engineering

FOR some time the National Roster of Scientific and Specialized Personnel, now a division of the U. S. Department of Labor, has been preparing occupational material, largely for the use of staff members of the United States Employment Service, among which are two items of particular interest to agricultural engineers. One is a handbook on the description of the specialized field of agricultural engineering, which contains descriptions of five major divisions of agricultural engineering, including mention of related fields, as follows: rural electrification, agricultural machines and power, farm structures and utilities, processing of farm products, and soil and water conservation. Copies of this handbook may be obtained from the superintendent of documents, U. S. Government Printing Office, Washington 25, D. C., for 5 cents each. The NRSST has also prepared cardboard folders, 5x7 inches, which contain a breakdown of the aforementioned five major branches of agricultural engineering, together with a listing of functional specializations licensure, professional affiliations, civil service ratings, educational qualifications, etc. These folders can be obtained free on request in limited numbers from NRSST, 1006 U. St., N.W., Washington 25, D. C.

Personals of A.S.A.E. Members

Vincent J. Barlow, who served as a first lieutenant in the ammunitions supply branch of the Army during the war, is now on terminal leave and will be employed by the U. S. Soil Conservation Service when his leave expires in January of next year.

James E. Beamish, who during the war served as a lieutenant with the Royal Canadian Engineers, has recently been appointed assistant director of land clearing of the department of agriculture of the Province of British Columbia with headquarters at Victoria, B. C. His work will involve administration of the clearing of agricultural lands for farmers throughout British Columbia; mechanical equipment and power will be used to assist the farmers to increase their acreages to economic units.

Thomas H. Coulter recently resigned as vice-president of Universal Zonolite Insulation Company to become associated with the firm of Booz, Allen & Hamilton in Chicago, where he will be engaged in establishing a new department to develop new products and to organize new small companies for their manufacture and distribution.

Elmer R. Daniel recently resigned as head of the plumbing unit of the Rural Electrification Administration to accept appointment as household engineer with the agricultural engineering development division of the Tennessee Valley Authority at Knoxville.

Donald L. DuBois, who served as a lieutenant in the U. S. Naval Reserves during the war, has returned to civilian status and has been appointed assistant civil engineer on the Asotin and Walla Walla (Washington) soil conservation districts of the U. S. Soil Conservation Service.

George B. Duke, who for the past eight years has been employed as a designing engineer in the experimental department of Deere & Co., recently transferred to the sales department of the John Deere Plow Co., at Atlanta, Ga., and is now engaged in sales work.

Price Hobgood, who served as a captain in the army air forces during the war, has been returned to civilian status and is now associate professor of agricultural engineering at the A. & M. College of Texas, a position he left when called to active military duty.

William E. Hudson, who served with the 15th Cavalry, U. S. Army, with the rank of captain, during the war, has returned to civilian status and is resuming his duties as associate professor of agricultural engineering at the University of Georgia, where he will specialize in farm structure.

Edward A. Johnson, who served as an ensign in the U. S. Naval Reserves during the war, has returned to civilian status and has accepted employment as a conservationist, Forest Service, USDA. He will be engaged in research in watershed management and protection at the Intermountain Forest and Range Experiment Station at Ogden, Utah.

Edwin L. Miller, who served as an ensign and lieutenant in the Navy during the war, was recently returned to civilian status and has accepted a position as specialist in hay and corn drying and irrigation with McCune & Co., New Waterford, Ohio.

Ralph R. Parks, who served as a lieutenant-colonel in the 170th Ordnance Bn. of the Army during the war, has returned to civilian status and taken up his former work as associate professor of agricultural engineering extension at the University of Illinois where he will specialize in rural electrification and farm structures extension.

Richard L. Ranney, who during the war was engaged as an engineer in the office of the Chief of Ordnance, U. S. War Department, in special engineering work in the export packaging field, has accepted a position with the General Box Company, Chicago, as assistant to the vice-president in charge of research, and will start his new duties on January 2.

L. E. Sample, who served as a captain in the Anti-Aircraft Artillery, AUS, during the war, has returned to civilian status and is now employed as irrigation engineer by the Layne Atlantic Company of Orlando, Florida.

(Continued on page 526)

Personals of A.S.A.E. Members

(Continued from page 524)

Arnold B. Skromme, who has been employed as development engineer by the Firestone Tire and Rubber Company for several years, has resigned to accept a sales engineering position with the Autos Specialties Manufacturing Company at St. Joseph, Michigan.

E. J. Stirniman was recently appointed director of a newly organized engineering research department of the Hawaiian Sugar Planters Association, and his work will include studies of the mechanization of field, mill, and transportation facilities. The Association's agricultural consultant, *H. B. Walker,* completed a survey of methods used in various production areas of Hawaii late last year, and the data from this survey will serve as a background for the new research department which will function with the plantations in a broad program of organization and improvement which is expected to cost millions of dollars. Mr. Stirniman's work as an agricultural engineer has taken him to Australia, New Zealand, and South America, in the interest of the Caterpillar Tractor Co., and he spent 10 years in Russia in the organization of the Soviet program for farm mechanization. *(Continued, page 530)*

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Roger O. Ackerman, rural electrification specialist, General Electric Co., Schenectady, N. Y. (Mail) 1615 Lenox Rd., Schenectady 8.

G. W. H. Allen, rural specialist, The Hydro Electric Power Commission of Ontario, Toronto, Ont. (Mail) 25 Keystone Avenue, Toronto 13.

E. L. Barringer, farm machinery division, The Chek-Chart Corp., 624 S. Michigan Ave., Chicago 5, Ill.

Jack F. Bell, Ivor, Va.

Charles G. Burress, Narrows, Va.

Morgan W. Dawley, engineer, Chrysler Corp., Highland Park 3, Mich. (Mail) 12536 Lincoln Ave.

Guy F. Gardner, field and test engineer, Bradley Mfg. Wks. (Mail) 489 S. Wildwood, Kankakee, Ill.

Lawrence Harrison, president, Harrison Research, Inc.; managing director, Kenya Concessions, Ltd. (Mail) Suite 759-61, Roosevelt Hotel, New York, N. Y.

C. W. Hill, acting head, agricultural engineering dept., West Virginia University, Morgantown, W. VA.

Orval C. Hovey, Parshall, N. D.

John M. Johnson, extension agricultural engineer, University of Florida, Gainesville, Fla.

W. J. Lavigne, supervisor, rural service bureau, The Shawinigan Water and Power Co., 107 Craig St., W., Montreal, Que., Can.

Herbert Muffley, Muffley Farms, Easton, Pa.

E. W. B. vd Muijzenberg, adviser-director, horticultural engineering, Agricultural State College, Wageningen, Holland. (Mail) 5 Lawickse allèe.

Paul R. Sawyer, rural supervisor Northern Pennsylvania Power Co. (Mail) 707 Main St., Towanda, Pa.

Marvin L. Stark, field engineer; supervisor, farm building inspections, Farmers Mutual Reinsurance Assn., Grinnell, Iowa.

Paul E. Turner, district agricultural engineer, Cornell University. (Mail) 24 Platt St., Albion, N. Y.

Theodore F. Wiederhold, farm productive equipment specialist, General Electric Supply Co., 961 Busti Ave., Buffalo, N. Y.

Charles H. Youngberg, design engineer, Deere and Mansur Wks., Moline, Ill. (Mail) 2720-11th Ave.

TRANSFER OF GRADE

William A. Cornwell, Lt. USNR, U.S. Navy CASU 6, Fleet P.O., San Francisco, Calif. (Junior Member to Member)

George H. Dunkelberg, associate agricultural engineer; South Carolina Agricultural Experiment Station, Clemson, S. C. (Junior Member to Member)

Lawrence Ennis, Jr., specialist, cotton ginning, Alabama Agricultural Extension Service, Auburn, Ala. (Junior Member to Member)

Harold F. Morgan, partner, Washington Equipment Co., Tennille, Ga. (Junior Member to Member)

Emanuel A. Olson, U. S. Army. (Mail) 3785 H St., Lincoln, Neb. (Junior Member to Member)

Donald C. Timberlake, farm equipment specialist, General Electric Supply Co., 401 East Canal St., Richmond, Va. (Junior Member to Member)

Harold D. White, associate professor of agricultural engineering, University of Georgia, Athens, Ga. (Junior Member to Member)

Personals of A.S.A.E. Members

(Continued from page 526)

Richard L. Witz has resigned as extension specialist in agricultural engineering at Michigan State College to accept a position in agricultural engineering research at the North Dakota Agricultural College at Fargo.

Necrology

RALPH L. PATTY, chairman, department of agricultural engineering, South Dakota State College at Brookings, passed away November 6 following a short illness.

Professor Patty was born at Redfield, Iowa, in 1884. In 1907 he received a degree from the Iowa State Teachers College, and in 1916 the degree of bachelor of science in agricultural engineering from Iowa State College.

He first went to Brookings, in 1919, where he was principal of the high school for four years. Then in 1916, following his graduation from Iowa State College, he returned to Brookings as extension agricultural engineer for South Dakota, in which capacity he served for eight years. In 1924 he was made chairman of the department of agricultural engineering at South Dakota State College which position he held until his passing.

Professor Patty was enrolled as a member of the American Society of Agricultural Engineers iin 1918 and took an active part in committee work in the Society in the fields of drainage, sanitation, barn ventilation, agricultural engineering extension, and rammed earth building. He was especially noted in the agricultural engineering profession for his extensive experimental studies with rammed earth as a building material. His bulletin, entitled "Rammed Earth Walls for Farm Buildings," was probably the most comprehensive work that has been published on the subject.

Besides his membership in A.S.A.E., Professor Patty was a member of the South Dakota Society of Architecture and Engineering and of the local Rotary Club, and he was also an honorary member of the Sioux Falls Engineering Club. He played a prominent part in community activities, serving on the Brookings park board and chamber of commerce and on the state planning board committee.

Professor Patty is survived by his wife, a daughter, three brothers and three sisters.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request.

POSITIONS OPEN

DESIGN ENGINEERS (12) for combines, corn pickers, hay balers and tractors. Midwest farm machinery manufacturer. Salary, $250 to $325 a month. O-401

SALES ENGINEERS (3) to work with dealers, farmers, etc, Large distributor of specialized farm equipment in five states. Salary and commissions to net $5000 to $8000. O-409

LABORATORY TECHNICIAN for chemical analysis of feeds, etc. Midwest farm supply company. Salary open. O-412

ASSOCIATE AGRICULTURAL ENGINEER for sales promotion of building materials. Building materials manufacturer. Location, Middle West. Salary (middle range), $3600 to $4200. O-413

FIELD ENGINEER for promotional and extension work on farm buildings in the south. Lumber trade association. Salary open. O-428

EXTENSION AGRICULTURAL ENGINEER to specialize in farm buildings. Southern state college. Salary open. O-430

RURAL ELECTRIFICATION SPECIALIST for teaching and research. Southern state college. Salary open. O-434

AGRICULTURAL ENGINEER for design, promotion and extension work on farm structures. Middle West building materials manufacturer. Salary, $250 to $300 per month. O-445

AGRICULTURAL ENGINEERS (5) to advise and assist power distributors in use of electricity on farms in Tennessee Valley. Federal agency. Salary, $3000. O-446

ENGINEER for laboratory testing and research on farm machinery, tractors and engines. Midwest farm machinery manufacturer. Salary open. O-447

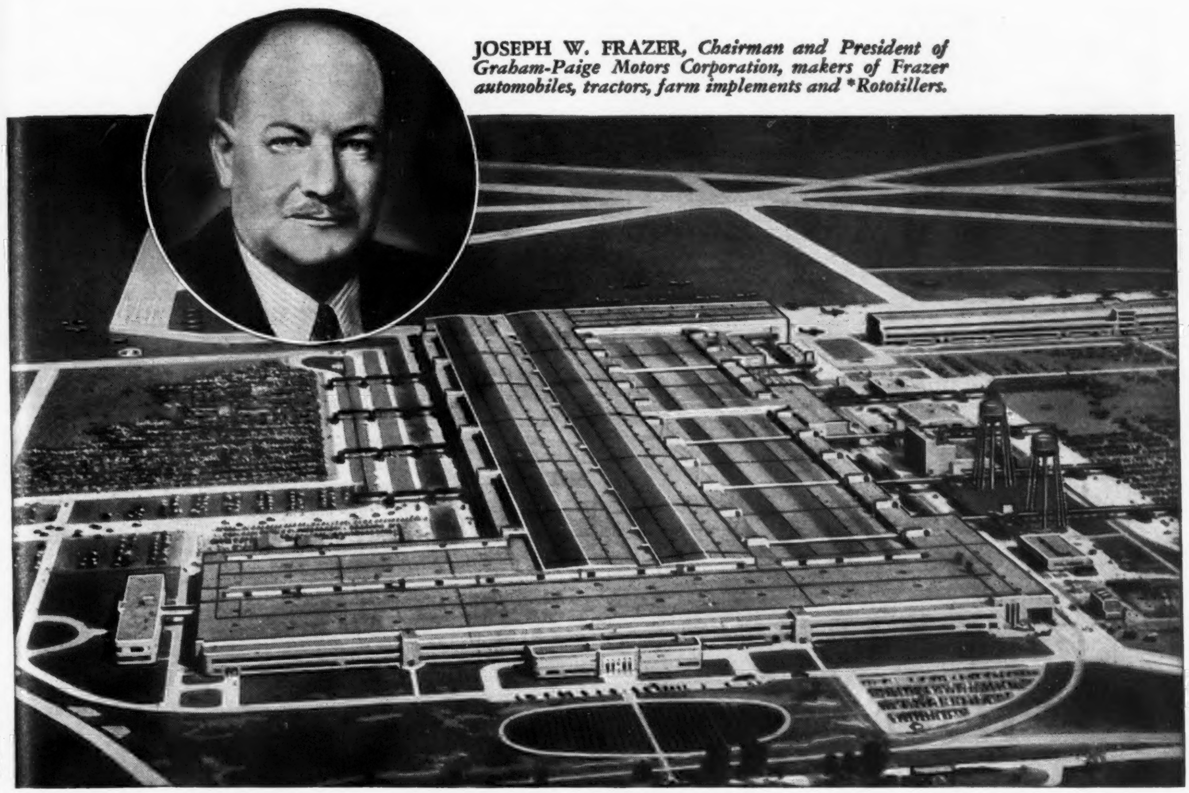
SALES ENGINEER to contact and assist design engineers of farm machinery in design of power transmissions. New England power transmission manufacturer. Salary open. O-448

ASSISTANT EXTENSION AGRICULTURAL ENGINEER as full-time specialist in safety and farm buildings work. Eastern state college. Salary, $3000 or more. O-449

ASSISTANT OR ASSOCIATE AGRICULTURAL ENGINEER for research and teaching in irrigation, soil erosion, and land development work. Western state college. Salary, $3000 to $3600. O-452

(Continued on page 532)

JOSEPH W. FRAZER, *Chairman and President of Graham-Paige Motors Corporation, makers of Frazer automobiles, tractors, farm implements and *Rototillers.*



WILLOW RUN—*where Graham-Paige will build* *ROTOTILLERS, FRAZER TRACTORS *and other farm equipment!*

The world's most famous war plant, at Willow Run, Michigan, is now being converted to serve the peacetime needs of two vital industries—civilian transportation and agriculture! Tomorrow this great bomber plant will begin to hum with the production of FRAZER automobiles, Rototillers, and the new line of Frazer farm equipment.

Here Joseph W. Frazer and his big staff of experienced farm equipment engineers will produce a notable array of modern tractors, implements and power tillage machines.

Heading the farm equipment line will be the sensational new FRAZER tractor. A good powerful universal-type farm tractor with a full 2-plow capacity, it will offer several long-sought features never before available at popular prices.

Various models of the ROTOTILLER, in both walking and tractor-operated types, will also be in mass production at Willow Run. This unique power tool is based on a time-tested principle that promises to revolutionize tillage methods. It saves labor, increases crop yields, and affords practical means of saving and building the soil.

Many other new and highly-improved farm machines, implements and tractor attachments are being developed and field-tested at Willow Run. It will pay anyone who is interested in the future of power farming to "keep watching the news from Graham-Paige!"

DEALERS ATTENTION: Choice farm equipment dealer territories are still open at Graham-Paige. Write us territory desired, stating your qualifications. Address:

GRAHAM-PAIGE MOTORS CORPORATION, WILLOW RUN, MICHIGAN

FARM EQUIPMENT DIVISION

*Trade Mark Reg. U. S. Pat. Office

Keep watching the news from GRAHAM-PAIGE!

PERSONNEL SERVICE BULLETIN

(Continued from page 530)

IRRIGATION ENGINEER for experimental work on use of water in irrigation, etc. Midwest state college. Salary, $3400 or more. O-456

DISTRICT MANAGER to make recommendations for and sell electric fly-screen installations in central New York state. Eastern manufacturer. Salary, $3000 to start. O-458

DESIGNERS, class A (3), for design of grain, corn, hay, and silage harvesting machinery. Midwest farm machinery manufacturer. Salary, $275 per month (min). O-459

DESIGNERS, class B (3), for layout work on grain, hay, and silage harvesting machinery. Midwest farm machinery manufacturer. Salary, $235 per month minimum. O-460

AGRICULTURAL ENGINEER (assistant professor rank) for teaching and research work in all branches of agricultural engineering, Eastern state college. Salary, $2800 per year. O-461

AGRICULTURAL ENGINEER for drafting, design, and development work on farm machinery. Eastern farm equipment manufacturer. Salary open. O-462

RESEARCH SCHOLARSHIP in connection with dairy barn research project. Midwest state college. Salary, $1400, with opportunity to carry up to 5 credits of college work. O-464

PROMOTION DIRECTOR to supervise and plan structures activities in farm and industrial fields, at Midwest location. Eastern trade association. Salary, $6000 to $7500. O-465

JUNIOR PROMOTION MAN (on farm structures) to prepare publicity, advertising, etc., and to work with colleges, 4-H clubs, etc., at Midwest location. Eastern trade association. Salary, $3500. O-466

AGRICULTURAL ENGINEER to develop and design pumps and other farm implements. Western New York farm machinery manufacturer. O-469

RESEARCH FELLOWS (3) in agricultural engineering with opportunity to carry full-time graduate study leading to master's degree. Midwest experiment station. Salary, $540 for 9 months. O-470

COPYWRITERS (2) for tractors and tractor-mounted and tractor-driven implements and machines. Midwest farm machinery manufacturer. Salary $150 to $325 per month. O-471

FARM STRUCTURES ENGINEER to carry on extension work looking to improvement of farm housing and rural sanitation and to assist in design of concrete structures. Midwest trade association. Salary commensurate with experience and ability. O-472

SALES PROMOTION ENGINEER (writer) to collect material and then edit magazine for rural builders and farm leaders, as well as prepare other promotion literature. Midwest trade association. Salary commensurate with experience and ability. O-473

ENGINEER to design corn planters, grain drills, manure spreaders, harrows, and other farm implements to gradually replace present chief engineer approaching retirement. Midwest farm mach mfr. Salary open. O-474

TWO JUNIOR ENGINEERS to work on detail design of spray machinery including assistance in redesigning high-pressure pumps, guns, tanks, vehicles, and practically an entire new line of products. Midwest farm mach. Salary $2500 at start. O-475

ASSOCIATE EDITOR to write stories and do other editorial work on rural electrification trade publication. Eastern publisher. Salary $200 to $250 per mo. O-476

AGRICULTURAL ENGINEER to take responsible position with a large farm management organization serving 50 farms and other rural industries in Ohio, to handle problems in farm mach, farm structures, rural electrn, soil and water conservn, and farm work simplification. Salary $3000 to $5000. O-477

ENGINEERS for conservation work with U. S. Soil Conservation Service. Entrance salaries, $2320 (P-1) and $2980 (P-2). (A.S.A.E will refer interested persons to appropriate SCS regional offices on request.)

POSITIONS WANTED

SALES ENGINEER desires sales and/or eng work in southwest U.S. on salary or commission basis. Ten years' wholesale farm tractor and mach sales, collection and service experience. Age 42. W-204

AGRICULTURAL ENGINEER (B.S. degrees in both ag and ag-eng.) desires teaching, extension or research work in power and machinery. Age 39. W-213

AGRICULTURAL ENGINEER (B.S. degree) desires sales or sales engineering and service or design and development work in farm structures field. Age 35. War veteran. Salary, $5000. W-219

AGRICULTURAL ENGINEER (B.S. degree) desires sales engineering and service or research and development work in private industry in soil conservation, rural electrification, or power and machinery field. Age 25. War veteran. Salary, $2500. W-220

AGRICULTURAL ENGINEER (B. S. degree) desires development, research or sales work in power and machinery or rural electrification field. Age 24. War veteran. W-221

AGRICULTURAL ENGINEER (B.S. degree) desires design and development or sales engineering and service work in farm structures field. Age 26. War veteran. W-224

AGRICULTURAL ENGINEER (B.S. degree) desires teaching and extension or research work in rural electrification or farm structures with public service agency. Age 27. Salary, $225 to $325 per month. W-226

AGRICULTURAL ENGINEER (B.S. degree in both Ag. and M.E.) desires design and development work in farm machinery field. Age 29. Salary, $350 per month minimum. W-227

AGRICULTURAL ENGINEER (B. S. degree) desires sales engineering or service work in power and machinery, rural electrification, or soil and water field, with public service agency or private industry. Age 25. War veteran. W-229

AGRICULTURAL ENGINEER (B.S. degree) desires design and development or research work in farm structures or soil and water field, either private industry or public service. Age 35. Salary, $5000. W-230

AGRICULTURAL ENGINEER (B.S. and M.S. degrees) desires research, teaching, and/or extension work in rural electrification with public service agency or in private industry. Age 35. Salary, $4000 to $8000. W-231

(Continued on page 534)

PERSONNEL SERVICE BULLETIN

(Continued from page 532)

AGRICULTURAL ENGINEER desires design, development, research sales or sales engineering and service work in farm structures field *only*, in either private industry or public service. Age 40. Salary, $4500 minimum. W-233

AGRICULTURAL ENGINEER (B.S. degree) desires sales engineering and service work in farm machinery field. Age 30. War veteran. W-234

AGRICULTURAL ENGINEER (B.S. degree) desires design and development work in farm machinery or farm structures field in either private industry or public service. Age 30. Salary, $3600. W-235

AGRICULTURAL ENGINEER (B.S.A. and M.A. degrees, major in ag-eng) desires sales engineering and service work in farm machinery industry, or power and machinery or soil and water work with federal agency or state extension service. Age 43. War veteran. W-236

AGRICULTURAL ENGINEER (B.S. degree) desires design and development or sales engineering and service work in farm machinery field or research and development in soil and water field. Age 26. War veteran. Salary, $3200 to $3500. W-237

AGRICULTURAL ENGINEER (B.S.A. degree, major in ag-eng) desires college teaching or extension, or service work with private company in power and machinery field. Age 36. Salary $2600 (minimum). W-239

AGRICULTURAL ENGINEER (B.S. degree) desires service or research work in farm machinery or rural electrification field, with private company or college. Age 31. Salary $2000 and up. W-240

AGRICULTURAL ENGINEER (B.S. degree) desires research, design, or sales engineering work in rural electrification with private company or public agency. Age 30. Salary $3200 to $3600. W-242

AGRICULTURAL ENGINEER (B.S. degree) desires service or research work in rural electrification or farm structures field with private company or government agency. Age 28. Salary $200 per month. W-243

SALES REPRESENTATIVE, with 26 years' experience in implement and tractor fields, desires sales work with farm machinery company. Age 55. Salary open. W-246

AGRICULTURAL ENGINEER (B.S. degree) desires sales engineering and service work in power and machinery with private company. Age 30. Salary $200 to $250 per month. W-248

AGRICULTURAL ENGINEER (B.S.A. and B.S. C.E. degrees) desires design, construction, service, research or sales work in farm structures field with private company, government agency, or state college. Age 31. Salary $4200 to $4800. W-249

AGRICULTURAL GRADUATE (B.S.A. degree, major in ag eng and minor in physics) desires research, teaching, or extension work in rural electrification, farm structures, or soil and water field with state college. Age 44. Salary $2900 minimum for 9 months. W-250

AGRICULTURAL ENGINEER (B.S. degree) desires research, service or extension work in farm machinery, rural electrification, or soil and water field with private company, government agency, or college. Age 26. Salary open. W-252

AGRICULTURAL ENGINEER (B.S. and M.S. degrees in ag engineering) desires teaching and research (or extension) work in farm structures or power and machinery field with land-grant college. Age 36. Salary $3600. W-253

LANDSCAPE ENGINEER, with several years experience with state highway department, REA cooperative on construction, and construction in soil and water field, desires sales or sales promotion work in farm structures or power and machinery field. Age 35. Salary open. W-254

AGRICULTURAL ENGINEER (B.S. and M.A. degrees in agriculture and B.S. in ag engineering) desires research or research and development work with government agency or private company or teaching and research with land-grant college. Age 32. Salary $4500 to $6000. W-255

AGRICULTURAL ENGINEER (B.S. degree) desires employment in farmpower and machinery field. Age 31. Salary $3000. W-256

AGRICULTURAL ENGINEER (B.S. degree) desires work in research, design or development in power and machinery or soil and water field. Age 28. Salary $2500. W-257

AGRICULTURAL ENGINEER (B.S. degree) desires sales, sales engineering, or development work with private company in power and machinery or farm structures field. Age 31. Salary $3600 minimum. W-258

AGRICULTURAL ENGINEER (B.S. degree) desires design and development work with private company in farm machinery field. Age 30. Salary $325 to $350 per month. W-259

AGRICULTURAL ENGINEER (B.S. deg) desires work in rural electrn or in soil conservn with either private company or public service agency Age 25. Salary $3000 (min). W-260

AGRICULTURAL ENGINEER (B.S. deg in both agr and civil eng) desires design, development or research work (or hydrologic work requiring meteorological training and experience) in soil and water field with public service agency. Age 28. Salary $3000. W-261

AGRICULTURAL ENGINEER (B.S. deg) desires sales and service work in farm mach field or dealership with well-known farm mach mfr, or soil and water development work. Age 27. Salary $3000. W-262

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or rural development work in rural electrn, power and mach, or soil and water fields with private company or federal agency. Age 40. Salary $4200 to $5000. W-263

AGRICULTURAL ENGINEER (B.S.A. and B.A.E. degs) desires work in functional design with private company or teaching and extension work in Midwest college in the field of farm mach or farm structures. Age 26. Salary open. W-264

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or service work with farm mach company or field engineering in soil erosion control with federal agency. Age 34. Salary $4500. W-265

AGRICULTURAL ENGINEER (B.S. deg) desires design, development or research work with private company in farm mach or farm structures field. Age 29. Salary open. W-266

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng work in rural electrn or farm mach with private company. Age 29. Salary $250 per mo. W-267

(Continued on page 536)

FACTS
about
GALVANIZED
SHEETS
ZINC INSTITUTE
2 OZ
COATING
SEAL OF QUALITY

PROFESSIONAL DIRECTORY

GEORGE R. SHIER, A. E.

Consulting Engineering Work In Farm Structures Field

Also Sales Engineering for Selected Manufacturers

Member A.S.A.E. Associated with Howard S. Sterner Company, Consulting Structural Engineers. 30 East Broad Street, Columbus, Ohio

FRANK J. ZINK ASSOCIATES

Agricultural Engineers

Consultants on product development, designs, research, market research, public relations

FELLOW A.S.A.E. Suite 4300, Board of Trade Bldg.
MEMBER S.A.E. Telephone: Harrison 0723 Chicago 4, Illinois

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 534)

AGRICULTURAL ENGINEER (B.S. in agr, major in agr eng) desires development, research or sales eng work with farm mach mfr, or project eng work in soil and water field with federal agency. Age 28. Salary $3500 (min). W-268

AGRICULTURAL ENGINEER (B.S. deg) desires research, extension or design and development work in rural electrn, farm structures, or power and mach field with a public service agency. Age 28. Salary $3200. W-269

AGRICULTURAL ENGINEER (Both B.S. and M.S. degs) desires sales eng work in farm buildings or rural electrn fields with private company. Age 26. Salary $3600. W-270

AGRICULTURAL ENGINEER (B.S. deg in both agr and agr eng) desires sales eng and service work with farm mach company or irrigation or other soil conservation work with public service agency Age 27. Salary $250 per mo. W-271

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or service work with farm mach company, or design and development work in farm structures. Age 28. Salary $2600 to $3000. W-272

AGRICULTURAL ENGINEER (Both B.S. and M.S. degs) desires development, research or sales eng work with farm mach company, or research or project eng work with federal agency. Age 36. Salary open. W-273

AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or research development work with farm mach company. Age 34. Salary $3500 (min). W-274

AGRICULTURAL ENGINEER (B.S. deg) desires work as development or project eng in product processing field. Age 28. Salary $3500. W-275

AGRICULTURAL ENGINEER (B.S. deg) desires design, development or research work with small power and mach company. Age 24. Salary open. W-276

CHEMICAL ENGINEER (B.S. deg) desires development or sales eng work in farm mach or product processing fields. Age 43. Salary $4000 to $5000. W-277

AGRICULTURAL ENGINEER (Both B.S. and M.S. degs) desires design or development work in rural electrn or farm structures. Age 30. Salary $4000. W-278

AGRICULTURAL ENGINEER (B.S. deg) desires development or research in rural electrn with private company or public service agency, or research or extension work in soil and water (irrigation) field. Age 27. Salary $2400 to $3000. W-279

AGRICULTURAL ENGINEER (B.S. deg) desires design or sales eng work in power and mach fields. Age 27. Salary $3000. W-280

AGRICULTURAL ENGINEER (B.S. deg) desires research or extension work with college or federal agency in power and mach or rural electrn. Age 27. Salary $2400. W-281

AGRICULTURAL ENGINEER (B.S.A. deg) desires development or research work in power and mach, farm structures, or rural electrn field with private company or federal agency. Age 32. Salary $3500 to $4000. W-282

AGRICULTURAL ENGINEER (B.S. deg) desires research and development work in farm mach with private company or college. Age 25. Salary $3000 (min). W-283

AGRICULTURAL ENGINEER (B.S. deg) desires design, development, sales eng or research work with farm mach company. Age 27. Salary $4000 to $5000. W-284

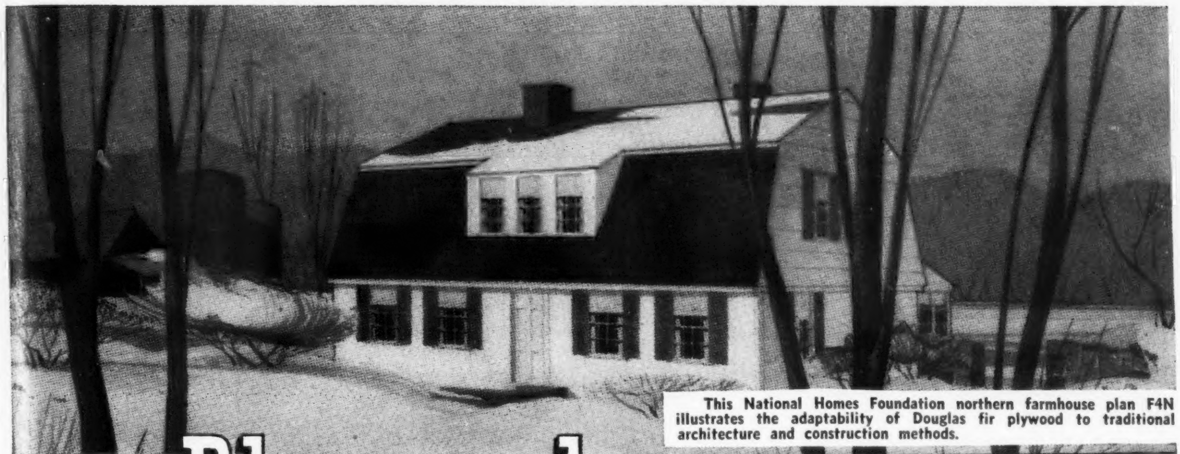
AGRICULTURAL ENGINEER (B.S. deg) desires sales eng or service work in farm mach or rural electrn field with private company. Age 29. Salary $3000. W-285

CHEMICAL ENGINEER (B.S. deg) desires development, research or service work in product processing field. Age 34. Salary $2000 (min). W-286

AGRICULTURAL ENGINEER (B.S. deg) desires design, development or research work in farm mach or soil and water field with private company or federal agency. Age 23. Salary $2600 to $3000. W-287

AGRICULTURAL ENGINEER (B.S.A. and B.A.E. degs) desires design or research in farm mach field or research work in soil and water field. Age 27. Salary $4000. W-288

Northern Farmhouse

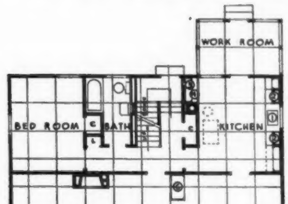


This National Homes Foundation northern farmhouse plan F4N illustrates the adaptability of Douglas fir plywood to traditional architecture and construction methods.

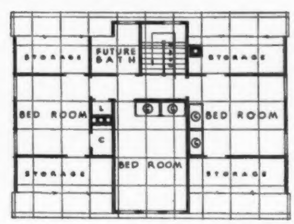
# of Plywood Construction

The National Homes Foundation, an informal organization of federal housing agencies and commercial concerns supplying building materials and equipment, selected a group of eight house plans suitable for urban and farm living under northern and southern conditions.

This plan shows one of the northern farm home designs constructed of Douglas fir plywood. The result is a sturdy, inexpensive house which will contribute to comfortable farm living.

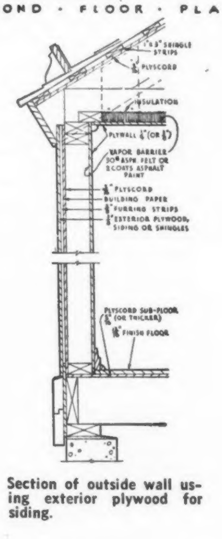


FIRST · FLOOR · PLAN



SECOND · FLOOR · PLAN

Legend—1. kitchen sink; 2, 3, 4, kitchen casework of plywood; 6, closets and storage units of non-structural, single-wall plywood construction.



Section of outside wall using exterior plywood for siding.

CONSTRUCTION SUGGESTIONS

FOUNDATION — Follow standard practice. Use PLYSCORD form sheathing for smooth, dense concrete walls.

FRAMING — Conventional.

SUB-FLOOR — For 13/16" wood flooring use 5/16" PLYSCORD length-wise across joists. Nail flooring to each joist. For linoleum use 5/8" PLYSCORD across joists with 2" x 4" headers cut between joists at panel joints. Cement felt and linoleum to sub-floor. (Where linoleum-floored areas open into wood-floored rooms, use ¾" panel under former to maintain even floor level.) Sound-one-side grade Exterior type panels properly finished with penetrating floor seal or floor enamel make attractive finish floors for bedrooms or other "secondary" rooms. Use 3/8" thickness over sheathing or ½" thickness on floor joists spaced 16" o.c.

INTERIOR WALLS AND CEILINGS — PLYWALL panels ¼" thick are adequate, but 3/8" thickness is recommended for greater ease in obtaining true surfaces. For panel effects lay out panel design and apply first panels at centers of areas, using V-joints or battens. Panels may be placed vertically or horizontally; battens may be either surface or inset mouldings. For smooth wall effect nail ¼" x 2¼" plywood furring strips to framing and glue panels to these. Cut in headers where necessary to support all panel edges. Apply vapor barrier outside of all panels on outside walls and top side of ceiling panels.

INTERIOR TRIM — For clean, modern effect fit plywood accurately to casings at openings, and bull-nose edges, or use narrow wood mouldings or narrow strips of ¼" plywood as trim. Use 4" or 6" strips of ¼" plywood with wood quarter-round as base moulding.

EXTERIOR WALLS — Apply 5/16" PLYSCORD sheathing horizontally across studs, building paper, 3/8" furring strips 16" o.c., and 3/8" EXTERIOR panels placed vertically or cut into wide horizontal siding. All horizontal joints must be flashed in butted joints, ship-lapped, or overlapped to drain. Coat all edges of EXTERIOR panels with heavy white lead paint before application, and apply with 6d galvanized box nails, spaced 6" at edges and 12" elsewhere. Conventional wood siding, shingles, brick or stone veneer, or stucco may be applied over the sheathing as a substitute for the EXTERIOR Douglas fir plywood siding.

INSULATION — Apply thermal insulation above ceiling and in outer walls as required by climate of locality.

ROOF — For wood shingles apply 5/16" or 3/8" PLYSCORD panels across the rafters for maximum rafter spacings of 20" and 24", respectively, and strip with 1" x 3" shingle lath. Or use ½" PLYSCORD across maximum rafter spacing of 30", and apply shingles direct.

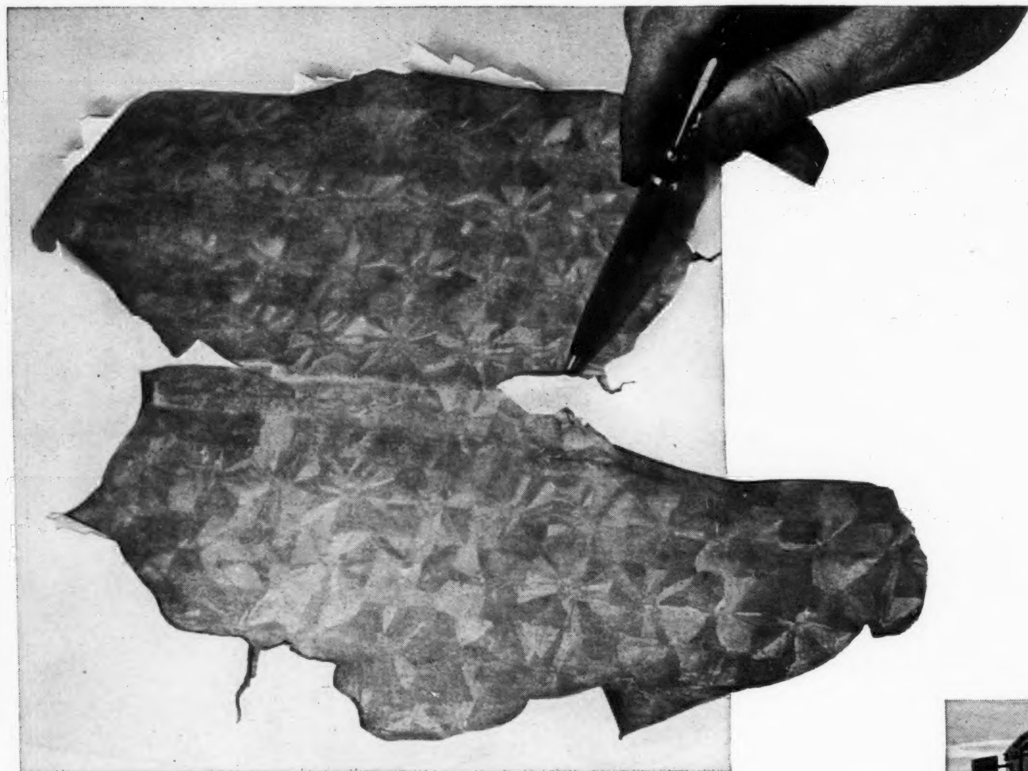
INTERIOR WALL AND CEILING FINISH — For panelled effects use stain, flat wall paint or enamel, or plastic paint on plywood surfaces. For smooth walls use flat wall paint or enamel, plastic paint, canvas painted or wallpaper. For the latter apply prime coat of paint to plywood, then smooth-surfaced building felt, and then wallpaper.

EXTERIOR WALL FINISH — Prime coat with raw linseed oil carrying moderate amount of pigment, and complete with standard mixed exterior paint of proven durability for local climate. In damp localities back-prime EXTERIOR siding.

Complete working drawings and material list of this farmhouse plan may be purchased through your lumber dealer from the National Plan Service, Chicago, Illinois. A key plan booklet illustrating and describing this design in greater detail is available from the

DOUGLAS FIR PLYWOOD ASSOCIATION
Tacoma 2, Washington

DOUGLAS FIR
PLYWOOD
LARGE. LIGHT. STRONG.
Real Wood
PANELS

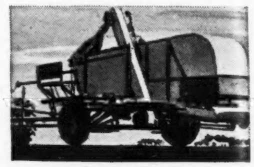


FARM EQUIPMENT DOESN'T HAVE TO SHOW ITS AGE

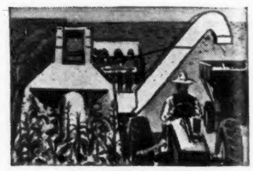
• Good galvanized sheet steel is a mighty useful metal—but it has one serious drawback. It can't take and hold paint. Even when acid-treated before painting, the raw zinc dries out the essential oils all too quickly and the paint starts to peel off—as you see in the picture. Then the farmer either has to repaint the equipment or let it become an eyesore to him and his neighbors.

• But equipment stays new-looking much longer when sheet steel parts are made of ARMCO Galvanized PAINTGRIP steel. This special-purpose sheet steel assures *triple protection:* 1. The steel base has a full-weight coating of zinc. 2. The coating is given the special *Bonderizing* treatment at the Armco mills. 3. This neutral surface grips and preserves the attractive paint finish.

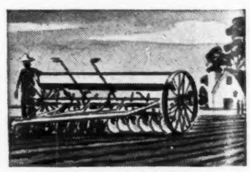
• If you don't have the complete story on this *special-purpose* steel write to The American Rolling Mill Company, 2101 Curtis Street, Middletown, Ohio. (Export: The Armco International Corporation.)



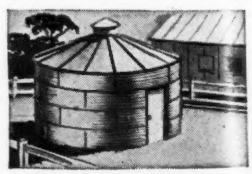
For combines



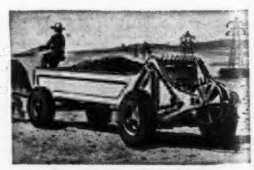
For corn pickers



For grain drills



For grain bins

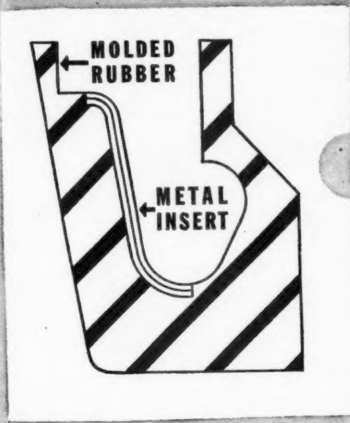


For manure spreaders

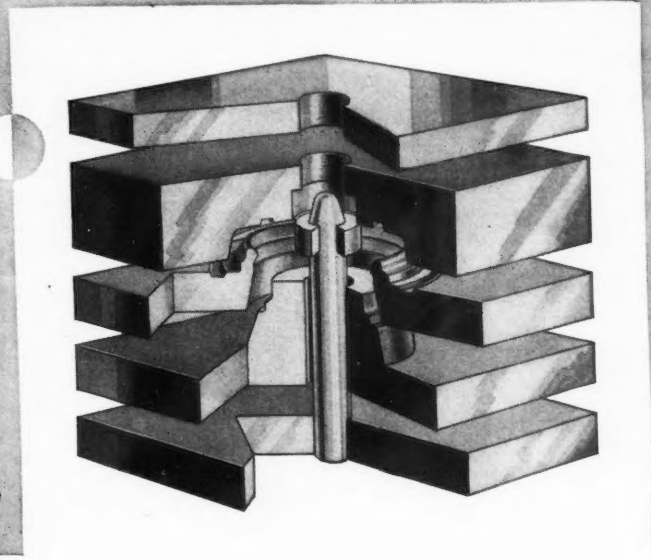
THE AMERICAN ROLLING MILL CO.

SPECIAL-PURPOSE SHEET STEELS

GALVANIZED PAINTGRIP ARMCO STEEL



"SIMPLE" PARTS



The relatively "simple" rubber-to-metal part indicated by the cross-sectional drawing above requires the complex, multiple-cavity mold illustrated at the right.

often demand

COMPLEX MOLDS

The "simple" rubber-to-metal part is not necessarily free of complications in producing it. As the above example illustrates, an intricate, multiple-cavity mold is required to produce the part that looks so "simple."

First consideration is the combination of conditions under which the finished part is to function. Next comes the design and manufacture of the mold to produce it. Then the correct compound of rubber or rubber-like material must be determined to meet both the molding and functional requirements. Exceptional precautions must be taken to prevent heat expansion from causing variations in the mold cavities, and often the mold cavities have to be registered individually with each other. Those and other related problems must be brought into "harmony" by modern techniques of the rubber industry. Briefly, it is a combination of "know-how" factors available here at "ORCO" that is causing an unprecedented demand for our services from a wide diversity of industries.

ORCO-OPERATION is a one word designation of complete cooperation in engineering and manufacturing mechanical molded and extruded rubber parts including rubber-to-metal adhesion parts . . . all available at The Ohio Rubber Company.

"ORCO-OPERATION"

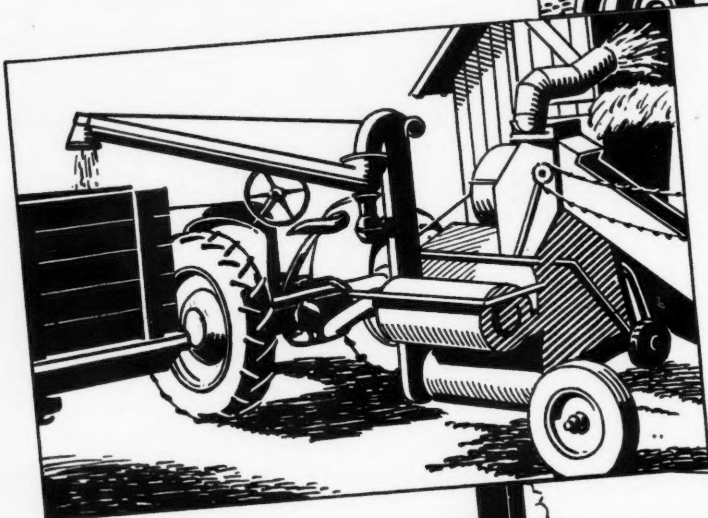
THE OHIO RUBBER COMPANY · WILLOUGHBY, OHIO

BRANCHES: DETROIT • NEW YORK • CHICAGO
INDIANAPOLIS • WASHINGTON • CLEVELAND

CONTINENTAL ENGINES

Power for the Farm

TODAY the power of Continental engines is being used in a score and more of applications in farm tractors and equipment. There are sound reasons why more and more leading farm equipment manufacturers are counting on Continental engines as their source of power.



RELIABILITY, easy maintenance, low cost operation are some of the prime requirements of a tractor engine. And full-length water jackets, removable tappets, roto valves, leak-proof water pumps, complete oil and dust seals are some of the reasons why Continental engines fully meet these requirements.

NO MATTER what your needs in the way of power for the farm, there's a Continental Red Seal Engine for your specific application. For more than forty-four years Continental has supplied dependable power for the farm.

POWER BY
Red Seal Engines
CONTINENTAL

Continental Motors Corporation
MUSKEGON, MICHIGAN

THERE'S A HOST OF FARM JOBS FOR A "CATERPILLAR" DIESEL "HIGH-LIFT"

THIS Traxcavator-equipped Diesel D4 is removing gravel to widen and deepen a creek channel—and to provide material for surfacing ranch roads. Owner of the outfit is Billy Creek Ranch Co., Bigtimber, Montana.

Built to employ the full power and traction of a "Caterpillar" Diesel Tractor, this unit can dig, lift, carry, load or spread an unusual range of materials—under a wide variety of conditions.

It can build a trench silo—provide a one-man pond-building outfit—build and repair levees, irrigation and drainage ditches—fill gullies. It can clean feed-lots, load or pile manure; it can load and help bin bulk grain and similar feeds; it can help install culverts. Its ownership can make special economic sense for the handling of agricultural lime in large quantities. A bulldozer blade can replace the bucket to add wider usefulness on such jobs as plowing snow from farm roads or moving dirt that doesn't need to be lifted or carried.

There are three sizes of "Caterpillar" Diesel Tractor-Traxcavator combinations—to team, respectively, with the D2, D4 and D7 Tractors. All sizes are sold and serviced by "Caterpillar" dealers.

CATERPILLAR TRACTOR CO., PEORIA, ILLINOIS

CATERPILLAR
REG. U.S. PAT. OFF.

DIESEL

ENGINES • TRACTORS
MOTOR GRADERS
EARTHMOVING EQUIPMENT

The discharged veteran wears this emblem. Remember his service and honor him.

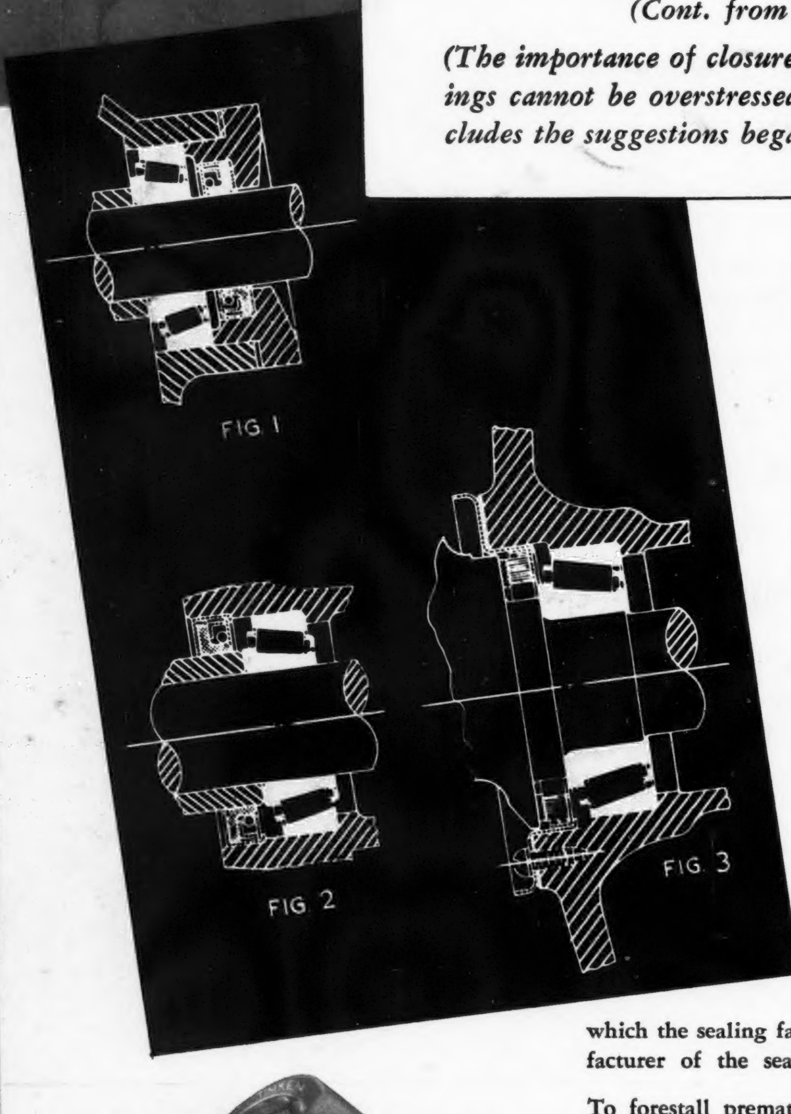

ROYAL FARM TRACTOR
U.S. TIRES
U.S. ROYAL
THE FARM TRACTOR TIRE
WITH A BACKBONE
SERVING THROUGH SCIENCE
UNITED STATES RUBBER COMPANY
1230 AVENUE OF THE AMERICAS · ROCKEFELLER CENTER · NEW YORK 20, N. Y.

Engineering Tips

ON CLOSURES FOR TIMKEN BEARING EQUIPPED FARM IMPLEMENTS

(Cont. from November)

(The importance of closures in connection with bearings cannot be overstressed. This advertisement concludes the suggestions began in the November issue.)



Figs. #1 and #2 illustrate commercial unit typ of seals used in gear boxes and wheels respe tively. These seals when properly install are very effective. The sealing element made from leather or some synthetic co pound. In installing be sure no damage done to the lip of the sealing surface. I some cases, it is desirable to chamfer th edges to facilitate assembly. When the pr mary function of the closure is to retai lubricant the lip should be turned in; i it is to exclude dirt, it should be turne out. Leather seals should be soaked in o before installation. When synthetics ar used the manufacturer of the seal shoul be consulted for installation instructions

Typical of recently developed side facing seals is the one illustrated in Fig. #3. The pressure holding the seal face in position is provided by sponge neoprene and the face itself is made from synthetic rubber or metal. Tests indicate that this type of seal is very effective both in retaining lubricant and excluding dirt. The surface on which the sealing face contacts should be well-finished. The manufacturer of the seal should be consulted regarding installation.

To forestall premature bearing wear manufacturers should study this problem carefully and provide adequate protection. This will enable Timken Bearings to provide full radial and thrust capacity for their entire rated life.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

THE TIMKEN ROLLER BEARING COMPANY, CANTON 6, OHIO

OR

TS

unit typ
els respe
install
lement
etic co
damage
rface. I
amfer t
n the pr
to retai
ned in; i
be turne
ked in o
netics a
eal shoul
structions

ide facing
g. #3. The
position i
nd the face
rubber o
ype of seal
ing lubri-
surface on
The manu-
stallation.

uld study
This will
t capacity